Popular Astronomy

Vol. LV, No. 1 JANUARY, 1947 Whole No. 541

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Meteors and Meteorites

Each issue of this magazine contains a number of pages of items for which the above furnishes a general heading. These items record principally the activities of two organizations, each composed of persons whose vocations or at least whose avocations are concerned with study and observation of these fleeting celestial phenomena.

Recently the interest of these persons and of people in general was greatly stimulated. A comet, passing near the sun, left in its wake many small particles of matter. A few weeks later the earth in its annual course around the sun passed through this same region. It was predicted that these small particles, being in rapid motion, would come into the earth's atmosphere, become heated as a result of friction, glow, and disappear. On October 9, at the precise hour, many persons were thrilled by the fulfillment of the prediction. They saw "showers" of "falling stars," such as they had never before seen, and such as have been reported in only a few instances.

Although such spectacular exhibitions of "falling stars" are rare, the earth's atmosphere is constantly enveloping large numbers of particles, thus giving rise to individual instances of the phenomenon. Authoritative estimates place the number of naked-eye meteors at one million an hour, in round numbers. In addition it is estimated that millions of times as many fainter ones occur. It would seem that, after the many years during which this has been happening, space would be swept clean of such stray matter. But as the sun and his family are coursing through space, the earth each year finds itself in pristine regions as far as meteoric material is concerned. So here again we are contemplating one of those cosmic processes apparently without beginning and without end.

Sometimes the particle involved is so large as to escape annihilation in the atmosphere and actually to strike the earth and thereby to become evidence of the kind of matter existing elsewhere. Meteors and meteorites thus constitute a continuous stream of messengers from outer space. But today the news contains the report of an attempt to reverse the direction. A rocket, traveling at a speed of more than a mile a second, at an altitude more than one hundred miles, is designed to hurl pellets which may move out into space and to all intents and purposes become uncaptured meteors.

This startling experiment is only incidentally related to meteors and

Bd. N. Meth. 9/27 1948 $ 2.96

meteorites. Its real purpose is the discovery, if possible, of the conditions imposed by nature on interplanetary travel of which it may be a beginning.

DECEMBER, 18, 1946.

Edmond Halley and His Times*

By SIR HAROLD SPENCER JONES†

During the 15th and 16th centuries a general change in intellectual outlook was taking place in southern and western Europe. The invention of printing played an important part in bringing about this new outlook, providing a means for spreading the new knowledge. The voyages of discovery were opening up new worlds, with profound effect on men's minds. The Pole, Nicholas Copernicus, had prepared the way for a profound revolution in men's minds, which was to change the whole outlook of man. His work was destined to destroy the proud belief of mankind that the earth was the centre of the Universe, that the Universe was made for it. But the immediate effect of his work on contemporary thought was not great. His immortal work "De Revolutionibus" received little attention; few copies were sold; the seed that he had sown lay dormant, but it did not die.

The great Danish astronomer, Tycho Brahe, was a most assiduous and systematic observer of the heavens, and contributed to the ferment of new ideas. He obtained a long series of observations of the new star of 1572 and established that the star was not a comet, as many had thought, and that it was more distant than Saturn. His observations of the great comet of 1577 proved that the comet was far more distant than the Moon. He thus introduced the principle of change into the changeless spheres, giving thereby a severe blow to Aristotelian principles. Tycho did not himself accept the Copernican theories. But his assistant, Kepler, did so from an early date. His success in establishing that the planets moved in elliptical orbits around the Sun was made possible only by the accurate and systematic observations of his great master. By providing a simple mathematical scheme of the material world, the foundations of Aristotelian cosmology were undermined and the whole edifice came crashing down in ruins. This remarkable discovery would not have been possible if Kepler had not accepted the heliocentric theory. It perfected the system of Copernicus and all that then remained to be done was to explain why the Earth and planets moved in accordance with the law that Kepler had enunciated.

In England the Copernican ideas seem to have gained earlier accept-

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*A paper presented on March 12, 1946, at the Copenhagen conference of representatives of the International Astronomical Union.

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ance than on the Continent. The English mathematician and astronomer, Thomas Digges (1546-1595), was one of the first advocates of the new views. He was probably the first to break definitely with the older cosmologies which had assumed the stars all to be at the same distance. Copernicus had himself admitted that the stars, once they were assumed to be at rest, might well be scattered throughout an infinite universe. But he declined to commit himself on the question, which he regarded as one for philosophers. In 1576 Thomas Digges revised the work of his father, Leonard Digges, the "Prognostication Everlasting," for a new edition and added a supplement describing the Copernican System, entitled "A Perfit Description of the Caelestiall Orbes," according to the most aunciente doctrine of the Pythagoreans, latelye reuiued by Copernicus and by Geometricall Demonstrations approued" with some paragraphs explaining his own ideas. In these he explicitly put forward the view that the universe was infinite. He refers to "this orbe of stars fixed infinitely up" and he has a clear conception of the stars appearing fainter with increasing distance until they become invisible:

> "Of whiche lightes celestiall it is to bee thoughte that we onely behoulde sutch as are in the inferioure partes of the same orbe, and as they are hygher so seeme they of lesse and lesser quantity, euen tyll our sighte not beinge able farther to reache or conceyue, the greatest part rest by reason of their wonderfull distance inuisible unto us."

The "Perfit Description" went through at least seven editions between 1576 and 1605, and had great influence on contemporary thought in England. It may be noted in contrast that 23 years elapsed before a second edition of the "De Revolutionibus" appeared and a further 51 years before a third edition appeared.

In 1583 there came to England the wandering humanist and renegade monk, Giordano Bruno. He may well have been influenced by Thomas Digges's ideas. He seems to have given some public lectures in England on Copernicus and his doctrines and in 1584 he published three small works in Italian, expounding his philosophy. One of these was entitled "Delle infinito Universo et Mondi." This book had no influence on English thought at the time and Bruno's speculations were practically unknown in England until some years later, when his Latin work entitled "De Monade" became available. Bruno's writings, though they consisted mainly of metaphysical speculation, undoubtedly helped to carry the Copernican revolution a stage further by dethroning the Sun and its planetary system from the central position in the universe and by insisting on the infinity both of space and of time.

The first attempt at a physical explanation of the rotation of the Earth was due to William Gilbert (1546-1603), the personal physician to Queen Elizabeth, who, in his "De Magnete," published in 1600, ascribed it to the magnetic properties of the Earth. He found that his

terella or magnetized sphere rotated under the influence of a magnetic field. The book is experimental in outlook and records numerous experiments. Though Gilbert's theory was not correct, it provided at the time a plausible explanation of the rotation and thereby removed an objection to the Copernican System; it was accepted by both Kepler and Galileo as a temporary hypothesis. The last section of the book is devoted to an explanation of the universe. The universe of Gilbert is that of Thomas Digges.

In the year 1609 in which Kepler published his book "De Motibus stellae Martis" Galileo Galilei (1564-1642) constructed his first telescope. In 1610 his discovery of the satellites of Jupiter was announced in the "Sidereus Nuncius"; in 1611 he observed the phases of Venus and Mercury and also discovered sunspots and the rotation of the Sun, which he announced in 1612 in the "Discorzo" and more fully in 1613 in the "Istoria e dimostrazioni." These observations of Galileo made it seem probable by analogy that the Earth rotated on its axis and that, with the other planets, it revolved around the Sun. When the attack on Galileo was made, the "De Revolutionibus" was placed on the Papal "Index" in 1616 and declared heretical. The book was only allowed to be read provided that all passages referring to the motion of the earth were altered to assert that this idea, though false, was introduced merely as a mathematical hypothesis to simplify the calculations.

By the latter part of the 16th century many had begun to feel that the explanation of natural phenomena offered by traditional authority no longer met their needs. They were seeking a surer guidance; they desired to measure, to weigh, and to control the conditions among which they lived, and, as Bacon wrote, "to extend more widely the limits of the power and the greatness of man." This desire the "new philosophy," with its scientific explanations, based on reliable evidence, seemed to meet, for it removed to a great extent the fear of the unknown and of the supernatural, as well as giving explanation of such phenomena as eclipses, comets, and earthquakes, which had hitherto been accepted as signs of divine or demoniac wrath and vengeance. Even the lesser superstitions, witchcraft, and so forth, were before long to lose much of the power they once had of disturbing the minds of educated men. In the new world that Copernicus, Galileo, and others had displayed, reason could now guide men's minds to satisfactory explanations with greater certainty than had hitherto been attainable. Scholastic thought had been primarily metaphysical, but Galileo and those who worked on similar lines had shown the wider fields of view which were open to those who concerned themselves with quantities rather than with qualities, and with facts which had been verified by repeated experiments. The new learning quickly spread through France, England, and elsewhere, through the correspondence which was carried on between scientific men in those countries, as well as by the visits of men of learn-

ing, many of whom travelled extensively in order to meet their colleagues in other lands.

In England, soon after 1640, at the time of the civil wars, a small group of men who were interested in the experimental, or New Philosophy as it was then called, made it their practice to meet weekly in London for talk and discussion, at the house of one of their number, or at a tavern conveniently near Gresham College, a weekly contribution being made for the charge of experiments. Dr. J. Wallis, one of their number, records that:

> "Our business was (precluding matters of theology and state affairs) to discourse and consider of *Philosophical Enquiries,* and such as related thereunto: as Physick, Anatomy, Geometry, Navigation, Staticks, Magnetics, Chymicks, Mechanicks, and Natural Experiments: with the state of these studies as then cultivated at home and abroad. We then discoursed on the circulation of the blood, the valves in the veins, the Venae Lactae, the Lymphatick Vessels, the Copernican Hypothesis, the Nature of Comets and New Stars, the Satellites of Jupiter, the oval shape (as it then appeared) of Saturn, the Spots in the Sun, and its turning on its own Axis, the Inequalities and Selenography of the Moon, the several Phases of Venus and Mercury, the Improvement of Telescopes, the grinding of Glasses for that purpose, the Weight of Air, the Possibility or Impossibility of Vacuities and Nature's Abhorrence thereof, the Torricellian Experiment in Quicksilver, the Descent of heavy Bodies, and the degrees of Acceleration therein; and divers other things of like nature."

On the restoration of the Monarchy in 1660 those who were in London resumed their meetings which had been discontinued in 1658, and others who had been in Oxford joined them; by the end of the year, they and a number of friends having similar interests resolved to constitute themselves a Society of Philosophers, which they succeeded in doing. Their project received the approval of King Charles II and the Society was incorporated by Royal Charter in 1662 under the title of the "Royal Society," the name having apparently been suggested by John Evelyn. It was Evelyn who also suggested the motto adopted by the Society—*Nullius in Verba,* which indicated the determination to test all statements by facts that had been carefully verified.

The object for which the Society was founded is defined in the Charter as being "for improving Natural Knowledge by Experiment," thereby excluding all that is supernatural.

Amongst the most distinguished of the early Fellows of the Society was Edmond Halley (1656-1742), a man of great versatility, breadth of knowledge and boundless energy. In every branch of knowledge that he cultivated, he achieved distinction. He was at once mathematician, astronomer, physicist, and statistician, geographer, hydrographer, and geomagnetician; navigator, practical seaman, and the first scientific voyager; scholar, diplomatist, and man of affairs. Overshadowed though he was in mathematics and physics by the unparalleled genius of Newton, yet it was the considered opinion of De Morgan that "if any one were to ask which we thought most likely, another Halley or

another Newton, that is, as extraordinary a man as the former or as the latter, we should reply—without denying the vast superiority of Newton in those points in which he was superior—that we should think the second more reasonably to be expected than the first."

It is about some of the achievements of Halley that I propose to speak tonight.

Amongst all his varied interests, astronomy was Halley's favourite pursuit, and by the age of 16 he had decided to devote himself to it. In 1673 he entered Queen's College, Oxford, studying mathematics and astronomy. Three papers by him on astronomical subjects appeared in the *Philosophical Transactions* in 1676. Halley soon realized that the progress of exact astronomy depended largely upon a more accurate knowledge of the positions of the stars. The observations of Flamsteed, at the newly established Royal Observatory at Greenwich, and of Hevelius were providing improved positions for the stars visible in northern latitudes. Halley tells us that he felt that if he, a novice, were to attempt anything similar, he would only be cackling stupidly among such stately swans. Without waiting to take his degree at Oxford, he decided with characteristic enterprise and energy, to make a voyage to St. Helena in order to determine the position of the brighter southern stars, which had not at that time been properly observed. On the recommendation of Sir Joseph Williamson, Secretary of State, and an alumnus of Halley's College, King Charles II sent a letter to the East India Company, desiring that Halley and his friend, a Mr. Clerke, might be granted a free passage to St. Helena. They sailed in November, 1676, in the *Unity*, Halley's father, a prosperous soap-boiler and merchant in the City of London, making him the generous allowance of £300 a year. Halley took with him a great sextant, specially constructed, of 5½ feet radius, fitted with telescopes in place of sights, his own 2-foot quadrant, and several telescopes of different focal lengths up to 24 feet.

Halley and his friend remained in St. Helena a whole year; the results of the observation were published in 1679 as the *Catalogus Stellarum Australium*, giving the longitudes and latitudes of 341 stars. In honour of his patron, he introduced a new constellation, *Robur Carolinum*, the Royal Oak in which King Charles II hid himself after the defeat at Worcester, which was later removed by Lacaille. Whilst on St. Helena, Halley observed the transit of Mercury of 1677 November 7, the fourth such transit of which there is any recorded observation, and the first in which both the ingress and egress were observed. In his catalogue he pointed out the utility of the observations of the transits of the inferior planets for determining the solar parallax.

This was his first allusion in print to a subject to which he was to return later, though he had mentioned the method in a letter written from St. Helena to Sir Jonas Moore.

Soon after his return the degree of M.A. was conferred on Halley, as the result of a letter from the King, dated Whitehall, 1678, November 18:

> "The King to the Vice-Chancellor of Oxford, to be communicated to the Convocation. Having received a good account of the proficiency in learning of Edmond Halley, of Queen's College, and especially as to the mathematics and astronomy, whereof he has given good testimony by his observations during his abode in the island of St. Helena, recommending for the degree of M.A. without any conditions of performing any previous or subsequent exercises for the same."

He was also elected a Fellow of the Royal Society, on November 30, being the anniversary election day. Within a year he set out, under the direct auspices of the Society, on a visit to Hevelius at Dantzig. There had been a vigorous controversy between Hevelius, who used the old-fashioned method of observing the positions of stars with open sights, and Flamsteed and Hooke, who favoured the telescope, about the relative accuracy attainable by the two methods. Halley took with him his telescopic sextant in order to make observations along with Hevelius. He was surprised at the skill shown by Hevelius in the use of the open sights, which he himself could not equal. The final result of the comparative observations was that Hevelius was more than ever confirmed in his old opinion, whilst Halley retained his preference for the telescopic sights. Within a couple of months of Halley's visit tragic disaster overtook Hevelius, his house, his observatory, and all his instruments being destroyed by fire.

Halley was still a young man when he rendered his greatest service to human knowledge by the share that he took in bringing Newton's "Principia" before the world. As De Morgan said "but for him, in all human probability, that work would not have been thought of, nor even thought of written, nor when written printed." Halley had married in 1682 and had taken up residence in London. He began to take a gradually increasing part in the activities of the Royal Society and in 1683 he was elected to the Council. Meanwhile, he had been trying to discover the law of force under which planets move in elliptical orbits with the Sun in a focus. He knew that for circular orbits, the force acting on each planet must vary inversely as the square of its distance from the Sun; but he was not able to solve the more difficult problem of the elliptic orbit, though he suspected that in this case also the force varied as the inverse square of the distance. In January, 1683-4, he raised the subject in conversation with Wren and Hooke. Wren informed him that he had given much thought to the problem but had been unable to solve it. Hooke affirmed that he had proved it, but when pressed to produce his solution he refused to do so. It seems certain that he was not able to give a mathematical proof. Wren, to encourage the inquiry being undertaken, said he would give Halley and Hooke two months in which to bring him a proof, and that he would present a book of the

value of forty shillings to whichever of them did it. Halley went home to struggle with the problem but without success. In August, 1684, therefore, Halley "did himself the honour," as he says, to visit Newton in Cambridge to consult him on the matter, having probably heard from Wren that Newton had discussed the subject with him some years before. Halley asked Newton what the curve described by the planets would be on the supposition that gravity diminished as the square of the distance. Newton immediately answered, an ellipse, and said that he had his demonstration by him. Not being able to lay his hands on it, Newton promised to send it to Halley later. He worked out the proof afresh, throwing it into a number of propositions, which he sent to Halley in November. Halley visited Newton again to make more inquiries and to urge him to develop his results, and to communicate them to the Royal Society. At the meeting of the Society on 10th December, Halley announced "that he had lately seen Mr. Newton at Cambridge, and that he had shown him a curious treatise *de Motu* which, upon his desire, he said, was promised to be sent to the Society to be entered upon their register." The minute in the Journal Book adds: "Mr. Halley was desired to put Mr. Newton in mind of his promise." About the middle of 1685 the tract *de Motu* was transmitted to the Society. In April, 1686, Dr. Nathaniel Vincent, a Fellow of the Society, presented a manuscript treatise entitled "Philosophiae Naturalis Principia Mathematica" and dedicated to the Society by Mr. Isaac Newton, "wherein he gives a mathematical demonstration of the Copernican hypothesis as proposed by Kepler, and makes out all the phenomena of the celestial motions by the only supposition of a gravitation towards the centre of the Sun, decreasing as the squares of the distances therefrom reciprocally." It was ordered that a letter of thanks be written to Mr. Newton, and that the printing of the book be referred to the consideration of the Council, and that in the meantime the book be put into the hands of Mr. Halley to make a report thereof to the Council. This manscript treatise is now one of the most treasured possessions of the Royal Society.

Early in 1686 Halley had been appointed to a new office, that of Clerk to the Royal Society: the responsibilities of the Society had increased and the need had been felt for a paid officer to relieve the Secretaries of routine duties, and to look after the general administration of the affairs of the Society. His salary was to be "after the rate of £50 per annum at the least." On 19th May the Society resolved that "Mr. Newton's 'Philosophiae Naturalis Principia Mathematica' be printed forthwith in quarto, in a fair letter: and that a letter be written to him to signify the Society's resolution and to desire his opinion as to the volume, cuts, etc." Halley wrote to Newton conveying this decision of the Society, referring to the book as "your incomparable treatise," and stating that the Society had resolved to print it at its own charge. But

the funds of the Society had been completely exhausted by the recent publication of a work, "De Historia Piscium" by Francis Willoughby, and even the salaries of the staff were in arrear. Somewhat later we find the Council voting that "Mr. Halley should have fifty copies of the History of Fishes instead of the £50 ordered him by the last meeting of the Council" and "that he should receive a gratuity of twenty other copies of the History of Fishes in consideration of his arrears in the last year." On the 2nd June the Council resolved that "Mr. Newton's book be printed, and that E. Halley shall undertake the business of looking after it, and printing it at his own charge, which he engages to do." This was a fine gesture on the part of Halley, who seems to have realized more than anyone else the tremendous importance of Newton's work. He was now possessed of but moderate means; his father had been found drowned in 1684 and he then became involved in a lawsuit with his stepmother on questions relating to his father's property and estate. But as the edition was quickly sold out and a second edition was soon exhausted, it is probable that Halley recovered most, if not all, of his outlay.

In the following March (1686-7) Newton sent up the second book of his treatise, dealing with motion in a resisting medium. The third book, dealing with the exemplification of his laws in the system of the known universe was presented to the Society in April, 1687. Newton tells us himself that he designed his work to consist of three books; but later, not being able to perfect the third book to his liking, he proposed to suppress it and it was only through Halley's persuasions that he agreed to retain it. Halley was occupied with details of the printing for more than a year, being, as he told Newton, "resolved to engage on no other business till such time as all is done, desiring to clear myself of all imputations of negligence in a business wherein I am much rejoyced to be any wais concerned in handing to the world that all future ages will admire."

The "Principia" established a view of the structure and workings of the universe which survived to our own generation. The mathematical demonstration of Kepler's laws of planetary motion in terms of universal gravitation was to lead eventually to the general acceptance of the heliocentric theory. The full extent and revolutionary character of the change that Newton was working in men's minds was not at first recognized even by himself, but it became apparent in the course of the eighteenth century. The essential revolutionary element was that Newton had conceived a working universe wholly independent of the spiritual order. This was the profoundest break that had yet been made with all for which the Middle Ages stood. With Newton there set in an age of scientific determinism. Halley played no small part in this: he bore all the stress, set aside his own researches, and sacrificed himself to forward what he regarded as the greatest of all scientific works.

Though Newton's work made Descartes' theory of vortices untenable, it was not at once universally accepted. The theory of vortices survived, in France for instance, until after the middle of the eighteenth century. The final acceptance of the Newtonian revolution was greatly helped by further work of Halley.

He quickly realized that some of the anomalies in the motions of the planets might be explained by their mutual gravitational attraction, by comparing ancient with modern observations, that the motion of Jupiter had been accelerated, and that of Saturn retarded. "It is more than probable," he wrote, "that this is owing to the mutual actions of the greater planets upon one another disturbing the centripetal forces of the Sun. . . We may justly hope that the errors we find in their motions, as they are owing only to the joint efficacy of three centres, at length may be removed by the Newtonian Geometry." But the complete explanation of the long inequality in the motions of Jupiter and Saturn was not to be found easily. It defeated Euler amongst others. Eventually in 1784 Laplace showed that, in consequence of the near commensurability of the mean motions of these two planets, certain terms on the differential equations of the longitudes which, depending upon the cubes of the eccentricities, would normally be very minute, are increased greatly in magnitude on double integration.

The secular acceleration of the mean motion of the Moon, discovered by Halley in 1693 from the discussion of ancient eclipse observations, proved even more difficult to explain. Laplace showed in 1785 that the eccentricity of the Earth's orbit decreases gradually as a result of the action of the planets on the Earth: this causes a gradual decrease of the mean action of the Sun upon the Moon, which depends upon the square of the eccentricity of the Earth's orbit, and a slow increase in the mean motion of the Moon is the result. The secular acceleration, as calculated by Laplace, was in close accordance with the observed value, but Adams found in 1853 that there was an error in Laplace's calculation and, when this was allowed for, the calculated acceleration proved to be little more than half the observed value. Within recent years, Taylor and Jeffreys have shown that the residual acceleration, not accounted for by Newtonian dynamics, is due to a gradual slowing down of the Earth's rotation by tidal friction in shallow seas.

But the most brilliant triumph for the Newtonian theory was to be provided by Halley's investigation of cometary orbits. Two conspicuously bright comets had appeared in 1680 and 1682, and Halley undertook the investigation of their orbits. So little was known about the orbits of comets at that time that when, after the comet of 1680 had disappeared near perihelion into the glare of the sun's rays, and later re-appeared on the other side of the Sun, Flamsteed identified the two appearances as being of the same comet, Newton was incredulous and believed that there had been two comets. He acknowledged his error

in 1685. The determination of the orbit of a comet was not an easy matter; convenient methods had not been devised and, moreover, the large errors inherent in the observations at that time made it necessary to use many observations. Newton employed methods that were in part graphical. Halley possibly undertook these laborious computations in order to relieve Newton of the task. In 1695 we find him writing to Newton suggesting that he would compute the path of the comet of 1680, if Newton thought it requisite; "being desirous as far as you will permit it, to ease you of as much of the drudging part of your work as I can, that you may be the better at leisure to prosecute your noble endeavours."

The first suggestion that the comet of 1682 had appeared before occurs in another letter to Newton of the same year: "I am more and more confirmed that we have seen that comet now three times since ye year 1531."

These cometary investigations were collected together in the important *Astronomiae Cometicae Synopsis,* presented to the Royal Society in 1705. Halley had collected all the recorded observations of 24 bright comets that had appeared from A.D. 1337 to 1698. He devised an arithmetical calculus for computing the orbits and gave a large General Table to facilitate such computations. He showed that these bodies which, according to M. Auzout, "all the world had been persuaded could not be reduced to any Laws" moved in orbits that were approximately parabolic. The latter part of the work was devoted to reflections on the probability that comets move in highly elliptical rather than in parabolic orbits: it was because of this probability that he had computed the orbits, so that when the orbit of a new comet had been derived it would be possible to tell whether it was a return of an earlier comet. However, as often happens in scientific work, the most important outcome was unexpected. It does not seem probable that, when he set out on his gigantic task, he had any expectation of the reward which he actually obtained.

He says that many things persuaded him that the comet of 1531 was the same as the comets of 1607 and 1682 and probably identical with one that had appeared in 1456, but had been only roughly observed. He referred to the intervals between the returns of this comet not being equal: they differed, in fact, by more than 15 months, which would have thrown some investigators off the trail. Ten years previously he had asked Newton to "consider how far a comet's motion may be disturbed by the centers of Saturn and Jupiter . . . and what difference they may cause in the time of the Revolution of a Comett in its so very elliptick orb."

He recalled the inequalities in the motions of Jupiter and Saturn and added "How much more liable to derangement then is a comet whose excursion into space is four times greater than that of Saturn and whose

orbit is so eccentric that, if the velocity were increased by 1/120 the part of its value, the ellipse described by the comet would be changed into a parabola." No means existed in Halley's time of computing a planetary perturbation, but he estimated that Jupiter's action would retard the next return of the comet and concluded "whence I would venture to predict with confidence a return of the same *anno scil* in 1758."

This was the first definite prediction from Newton's law of gravitation and, as the time for the expected return drew near, intense interest was aroused. The comet was first seen on 1758 December 25 by an amateur astronomer, George Palitsch of Saxony. Perihelion passage occurred on 1759 March 13, the return having been delayed, as Halley had foreseen, by the perturbing action of Jupiter though by a greater amount than he had assumed.

All the previous returns of this comet back to 240 B.C. have been computed by Cowell and Crommelin at Greenwich. Appropriate is it that this most famous of all comets will forever bear Halley's name.

Of all the comets in the sky
  There's none like Comet Halley,
We see it with the naked eye,
  And periodi—cally.
The first to see it was not he,
  But yet we call it Halley.
The notion that it would return
  Was his origi—nally.

In 1691 Halley had been a candidate for the Savilian chair of Astronomy at Oxford but he had not been elected, owing to Archbishop Tillotson's dislike of his views upon questions touching religion.

Halley was broad in his views, free in his expression of them, and not devoid of all tincture of levity and facetiousness. Thus, for instance, in a later paper explaining the cause of the saltness of the oceans he suggested that, by determining the rate at which the saltness increased, the age of the world could be discovered. The requisite data were not then available, but, with acute foresight, he added "perhaps by it the world may be found much older than many have imagined," an opinion that in his day was distinctly unorthodox. In 1704, however, he was elected to the Savilian Chair of Geometry, which he held until his death and, from 1720 onwards, concurrently with the position of Astronomer Royal. He now turned his attention to the neglected field of Greek geometry. In 1706 he published an edition of the lost work of Apollonius, "De Sectione Rationis," which he deciphered from an Arabic manuscript in the Bodleian Library. Knowing no Arabic, he used a few pages that had been translated by Dr. Bernard as a key to decipher the rest, and was able to make important critical emendations to the manuscript. He also added his own restitution of the two lost books "De Sectione Spatii," from the account given by Pappus. He then under-

took, in collaboration with David Gregory, the Savilian Professor of Astronomy, a complete edition of Apollonius. But Gregory's sudden death in 1708, in the early stages of this project, left the bulk of the work to Halley. The edition, published in 1710, remained the only printed Greek text of Apollonius until the end of the 19th century. The work included translations from the Arabic of the Vth, VIth, and VIIth books, and a restitution of the VIIIth book. It stands as a monument to Halley's industry and scholarship.

But in the meantime before his election to the Professorship of Geometry at Oxford, Halley's versatile mind had had scope in other directions. In 1694 he was appointed a member of a committee, which included Newton, to consider the re-coinage of the currency and to draft a bill to this effect which would be laid before Parliament. In 1696 Newton was appointed Warden of the Mint, on the nomination of his old Cambridge friend, Charles Montagu, the Chancellor of the Exchequer. Through Newton's influence, Halley was appointed Deputy-Comptroller of the Mint established at Chester during the great re-coinage of the silver currency. He remained there for two years, until the coinage was completed and the provincial mints closed down. His return to London in 1698 coincided with the visit to England of the Czar Peter the Great. Halley had by this time acquired a European reputation and Peter sought his views on the formation of a Russian navy and of the cultivation of the sciences in his Empire: it may be mentioned that an eventual development from this visit was the foundation of the St. Petersburg Academy of Sciences by Peter the Great. Peter and Halley had much in common and Peter had a particular liking for Halley's companionship; his hearty disposition was attracted to the frank, genial, and ardent nature of Halley.

In the autumn of 1698 we find Halley appearing in the role of a naval commander. Just how the transformation was brought about is not known: it was certainly a most unusual step to commission a landsman to the command of a King's ship. The object in view was the study of the variation of the compass in the Atlantic Ocean, in order to establish a theory of that phenomenon. The appointment was no doubt due to Halley's interest in terrestrial magnetism, the tides, and meteorology.

He had published in 1686 a paper entitled "An historical account of the Trade Winds, and monsoons, observable in the seas between and near the tropicks; with an attempt to assign the phisical cause of the said winds." This was based partly on his own observations and partly on data collected from a variety of sources. The paper included a chart showing the direction of the wind over the oceans between latitudes 30° N. and S. This was the first graphical representation of geophysical data on maps, and it is surprising that the world had to wait so long for such a convenient and simple method of representing a great mass of data; the chart was reproduced many times, in books and on navi-

gation maps. His attempt to assign the physical causes of the trade winds was imperfect and the correct explanation was first given, nearly 50 years later, by George Hadley. Halley had also been interested in problems of the tides and with the cause of the variation of the compass and of its secular change. He had disproved Gilbert's explanation of the variation of the compass as being due to the attraction of the continental land masses. In a subsequent paper he attributed four magnetic poles to the Earth, two being stationary and located in the outer crust, the other two lying in a concentric ring whose rotation lags behind that of the crust. Halley's attempt at an explanation was not successful and, in fact, the cause of the secular change of the Earth's magnetic field still remains obscure. But it was apparently his desire to test his theory more completely by increasing the available data which led to the granting to him of a naval commission.

His instructions, dated 15 October 1698, read as follows: "Instructions for proceeding to Improve the Knowledge of the Longitude and Variations of the Compasse. . .

> Whereas his Maty, has been pleased to lend his Pink the Paramour for your proceeding with her on an Expedition, to improve the knowledge of the Longitude and variations of the Compasse, which Shipp is now compleatly Man'd, Stored and Victualled at his Mats. charge for the said Expedition; you are therefore hereby required and directed, forthwith to proceed with her according to the following Instructions.
>
> You are to make the best of your way to the Southward of the Equator, and there to observe on the East Coast of South America, and the West Coast of Africa, the variations of the Compasse, with all the accuracy you can, as also the true Scituation both in Longitude and Latitude of the Ports where you arrive.
>
> You are likewise to make the like observations at as many of the Islands in the Seas between the aforesaid coasts as you can (without too much deviation) bring into your course; and if the Season of the Years permit, you are to stand soe farr into the South, till you discover the coast of the Terra Incognita, supposed to lye between Magelan's straights and the Cape of Good Hope, which coast you are carefully to lay downe in its true position.
>
> In your returne home you are to visit the English West India Plantations, or as many of them as conveniently you may, and in them to make such observations as many contribute to lay them downe truely in their Geographicall Scituation. And in all the course of your Voyage, you must be carefull to omit no opportunity of Noteing the variation of the Compasse, of which you are to keep a Register in your Journall."

In this ship, on the first sea voyage to be undertaken for a purely scientific voyage, Halley sailed for two years, October, 1698, to September, 1700, with a return to England in June, 1699, the reason for which is given in Halley's report to the Secretary of the Admirality:

> "A further reason to hasten my return was the unreasonable carriage of my Mate and Lieutenant, who, because perhaps I have not the whole sea Dictionary so perfect as he, has for a long time made it his business to represent me, to the whole Shippes company, as a person wholly unqualified for the command their Lordships have given me, and declaring that he was sent on board here, because their Lordships knew my insufficiency. Your Honour knows that my dislike of my Warrant Officers

made me Petition their Lordships that my Mate might have the Commission of Lieutenant, thereby the better to keep them in obedience, but with a quite contrary effect it has only served to animate him to attempt upon my Authority, and in order thereto to side with the said officers against me. On the fifth of this month he was pleased to affront me, as to tell me before my Officers and Seamen on Deck, and afterwards owned it under his hand, that I was not only uncapable to take charge of the Pink, but even of a Longboat; upon which I desired him to keep his Cabbin for that night, and for the future I would take the charge of the Shipp my self, to show him this mistake: and accordingly I have watcht in his steed ever since, and brought the Shipp well home from near the banks of Newfound Land, without the least assistance from him."

This was a striking instance of Halley's versatility.

In the second part of the cruise, in 1699-1700 in the South Atlantic, Halley went as far south as latitude 52½°, encountering Antarctic icebergs. Immediately on his return to England, he set to work on his material and in 1701 he published, for the use of seamen the chart of the variations of the compass in the Atlantic Ocean and in 1702, a chart of the variations over the whole world. The representation of the data by *curve lines,* as Halley called them, or *isogonic lines,* as they are now called, connecting the points at which variation has a given value, was due to Halley. The method is so convenient that it is in general use today; it was a most important contribution to practical navigation. In preparing these charts, he used not only his own observations but also all the available observations made by other seamen, whose collection and adaptation must have involved great labour.

Halley, in the description of his chart, referred to its use "to estimate the longitude at sea thereby" and pointed out places where this was possible, where the isogonic lines run approximately north and south, and where it was not possible, where they run east and west. The problem of determining the longitude at sea was still unsolved and great hopes were being put on the use of the variation of the compass; but Halley realized that it could not offer a complete solution of the problem.

In April, 1701, Halley proposed to the Admiralty an exact survey of the tides in the channel and offered his services for the purpose. Accordingly the Lords Commissioners renewed his commission to the *Paramour* and he was engaged on this tidal work from June to October, 1701. In the next two years we find Halley in a different role, being engaged on two diplomatic missions, being sent by Queen Anne to advise the Emperor Leopold concerning improvements to the harbours on the coasts of Istria and Dalmatia. Halley's record in applied science, in navigation and hydrography, no doubt led to his choice for this service—a service which he appears to have carried out greatly to the satisfaction of the Emperor, who presented him with a rich diamond ring and gave him at his departure a letter of high commendation.

Before leaving on his first cruise in the *Paramour* in 1698 Halley had

resigned his post as Clerk to the Royal Society. In 1703 he was elected to the Council and in 1713 he became Secretary, a post which he held until 1721.

In 1716, in an attempt to explain the principal phenomena of the aurora borealis, Halley made the first suggestion that the aurora borealis was associated with the earth's magnetism. He noted that the Northern Lights were never seen at the equator and that they were seen more often in Iceland and Greenland than in Norway, which was farther from the magnetic pole. He conjectured that they were due to "magnetic effluvia." It was not until 1741 that the relationship was definitely proved by Hiorter's observation at Upsala of the disturbance of the magnetic needle accompanying displays of the aurora.

In 1716 Halley published his important memoir on the determination of the Sun's parallax from observations of the transits of Venus. He emphasized the advantages of basing the determination solely on the observations of the times of the two internal contacts: these could be determined with accuracy he said, "without any other instruments than telescopes and good common clocks, and without any other qualifications in the observer than fidelity and diligence, with a little skill in astronomy." The exactness with which he believed the times of contact could be observed made him earnestly implore his countrymen not to neglect the valuable opportunities that the transits of Venus in 1761 and 1769 would afford for the accurate determination of the solar parallax. It was mainly because of the ability with which Halley expounded the advantages of the method and because of the weight of his authority in astronomical science that the principal governments of Europe fitted out expeditions to observe these transits—the first large-scale instance of international co-operation in astronomy.

The observations did, indeed, reduce the uncertainty with which the Sun's distance was determined, but not to the extent that Halley had been led to believe. The unforeseen phenomenon of the black drop made the exact instants of the contacts uncertain. The transits of 1874 and 1882 were again observed very widely but with disappointing results.

Halley was the first person to suspect that the stars have proper motions. By comparing the observations of Ptolemy with those of more recent times, he found in 1717 that Sirius, Aldebaran, and Arcturus were moving slowly towards the south, their latitudes having sensibly changed in the interval. These changes might have been due either to actual changes in the positions of the stars or to a displacement of the ecliptic. Halley was once again the pioneer, leaving the decision between the alternatives to the time when more accurate observations would be available.

At the end of 1719 Flamsteed died at Greenwich. A few weeks later, Halley, at the age of 64, was appointed to succeed him as Astronomer

Royal. In view of Halley's eminence no other appointment was possible. When he took up his duties at the Observatory he found it, as he tells us, "wholly unprovided of instruments, and indeed of everything that was moveable." Halley thus repeated Flamsteed's experience of being provided with an observatory without any equipment. Flamsteed had made extensive observations of the stars, but comparatively few of the Moon. Halley therefore planned to improve the current Tables of the Moon for the purpose of determing longitudes by the method of lunar distances, and for this purpose he proposed to observe the Moon through a complete revolution of the node—about 18 years. It was a characteristically bold enterprise for a man of his age to embark upon.

He continued the observations unaided from the beginning of 1722 to the end of 1739, and it is said that, during all that time, he scarcely ever lost a meridian view of the Moon, either by day or night, when the heavens would permit her to be seen. In 1731, when nine years' observations had been completed, he presented an account of the progress of the observations to the Royal Society; he stated that with the results it was posible to correct the Moon's position within 2′ of arc of her true place—an uncertainty which would correspond to one of twenty leagues in a longitude determination at the equator. This was the best result up to that time and seemed to bring the problem of the determination of longitude at sea within measurable reach of success. These observations were published, along with his general astronomical tables, in 1749, seven years after his death.

Halley's passionate admiration for greatness in scientific work, which was manifested so clearly in 1685, found almost equal expression in his closing years in his anxiety that Bradley should succeed him as Astronomer Royal, though his failing health intervened to prevent the proposal being carried into effect. It tells us something of his vigorous human nature that he incidentally founded the Royal Society Club, which still meets for dinner after the meetings of the Royal Society and of which the Astronomer Royal, as a tribute to his predecessor Halley, is *ex officio* a member. When he came up from Greenwich to the meetings of the Royal Society, he liked to dine with his friends; they collected round him, heads were counted, and so many pounds of fish bought (fish because Halley had no teeth) which the company proceeded to eat. So, in 1731, was initiated the Club which has by this time so notable a history.

The records of the Club relate that:

> "They then agreed to go to a house in Deans Court between an Alehouse and a Tavern, now a Stationer's Shop, where there was a great Draft of Porter, but not drunk in the House. It was kept by one Reynell. It was agreed that one of the company should go to Knights and buy fish in Newgate Street, having first informed himself how many meant to stay and dine.

> "The ordinary and Liquor usually came to half a crown, and the Dinner only consisted of fish and pudding. Dr. Halley never ate anything but fish, for he had no teeth . . .
>
> "About 1737 he (Halley) was seized with paralytic disorder in his right hand, which, it is said, was the first attack he ever felt on his constitution; however, he came as usual once a week, till within a very short time of his death, to meet his friends in town on Thursdays, the day of the Royal Society's meeting, at what is still called Dr. Halley's Club. His paralytic disorder increasing, his strength gradually wore away, till he expired Jan. 14, 1742, in the 86th year of his age."

It has not been possible to do full justice to the remarkable versatility of Halley's genius, for his investigations ranged over many fields. Pioneer work on vital statistics and mortality tables, the first application of the barometer to measure heights, a critical discussion of the place and time of the landing of Julius Caesar in Britain, improvements in the diving bell, application of algebra to the problems of lenses, contributions to gunnery and ballistics; these were but a few of the many other subjects with which Halley concerned himself.

In these days, when family allowances are under consideration in various countries and when the decline in birth-rate gives cause for concern, it is interesting to recall Halley's views on these sociological questions, written in 1693:

> "The strength and glory of a King being in the multitude of his subjects, I shall only hint, that above all things celibacy ought to be discouraged, as, by extraordinary taxing and military service: And those who have numerous families of children to be countenanced and encouraged by such laws as the *Justrium Liberorum* among the Romans. But especially, by an effectual care to provide for the subsistence of the poor, by finding them employment, whereby they may earn their bread, without being chargeable to the public."

The Latin inscription on his tomb ends with a passage, which, in translation reads:

"As when living he was so highly esteemed by his countrymen, gratitude requires that his memory should be respected." Halley had a share, and it was not a small share, in completing the revolution that had been begun by Copernicus. For that, if for nothing else, his name and memory will not be forgotten.

The Observation of Ten Total Eclipses*

By S. A. MITCHELL

From time to time I have appeared before the American Philosophical Society to present results from observations of total eclipses of the sun; the last time was in 1938 when I had the honor of giving the Penrose Memorial lecture. Today I wish to present the high-lights of four

*A paper read before the American Philosophical Society at the Annual meeting, April, 1946.

decades of my life spent in eclipse work, but leaving the technical details for publication elsewhere. In 100,000 miles of travel by land and sea, I have had an accumulated duration of totality of less than one-half hour, or 26 minutes, for securing the observations. In seven of the ten eclipse expeditions, assistance was given by the U. S. Navy, either directly, or indirectly through the Naval Observatory. For five expeditions, the Navy transported to destination personnel and equipment; for four eclipses, 1901 in Sumatra, 1905 in Spain, 1930 on Niuafoou (Tin-Can) Island, and 1937 on Canton Island, the Navy came ashore to help in the installation of the apparatus and to become assistants at the time of totality. I am eternally grateful to the Navy and to the Naval Observatory, for otherwise I could have accomplished nothing. In contrast, it might be added that neither I personally, nor the institutions represented (Columbia University for three expeditions and the University of Virginia for the balance), own one penny's worth of eclipse equipment. The spectrograph boxes, but one, always used, belong to the Naval Observatory, while the gratings needed were borrowed from Professor F. A. Saunders, from the Naval Observatory, from the Mount Wilson Observatory, and from Allegheny Observatory.

The first photographs of the flash spectrum[1] ever secured were at the eclipse of April 16, 1893, by Shackleton in Brazil and Alfred Fowler in West Africa, both observers then being assistants of Sir Norman Lockyer. (In passing, it might be interesting to note that a few hours after my latest eclipse on June 8, 1937, on Canton Island in the South Pacific, I had the pleasure of a two-way radio broadcast with my good friend for more than a quarter of a century, Professor Alfred Fowler, who in London was as far from me in distance as he could possibly be, namely, half way around the world.)

Wide-spread clouds were met for the eclipse of 1896, August 9, but Shackleton again photographed the flash spectrum. In spite of the poor definition obtained in these two early eclipses, Lockyer drew quite erroneous conclusions[2] by stating that in Rowland's Atlas there were 5694 Fraunhofer lines between the F and H lines, while in the same region there were only 164 chromospheric lines in the 1893 photographs and 464 at the 1896 eclipse.

Photographs of the flash spectrum, and in better definition, were obtained in India on January 22, 1898, by Fowler and Lockyer, by Campbell, by Hills, by Newall, and by Evershed. Such was our knowledge of the spectrum of the chromosphere when I, almost a pioneer, went to my first eclipse.

With the path of totality running diagonally across the southeastern states from New Orleans to Norfolk, it was natural that for the 1900 eclipse the Johns Hopkins University, the home of Rowland gratings,

[1] Mitchell, "Eclipses of the Sun," p. 160.
[2] Lockyer, "Recent and Coming Eclipses," p. 111.

should play an important part. I was in Griffin, Georgia, on May 28 and acted as the assistant to L. E. Jewell of Hopkins. The results of this eclipse are given in detail in *Publications of the U. S. Naval Observatory,* Second Series, Vol. IV, Appendix 1, 1905. My first eclipse taught me valuable lessons for my guidance on possible future expeditions. On account of the normal spectrum obtainable, it seemed wisest to use grating rather than prism spectrographs; secondly, for a grating spectrograph a slit seemed quite unnecessary; and thirdly, the securing of good focus with a slitless instrument was a long drawn-out task requiring that the expedition be a long time on the spot in preparation.

My second expedition, in 1901, meant a trip almost exactly half way round the world, 30 days by Army Transport from San Francisco to Manila, and then an additional 10 days by Navy to the West Coast of Sumatra, where we were for a total of eight weeks. There I was pleased to meet Dyson, later the Astronomer Royal, and also Professor and Mrs. Newall, of Cambridge University, the three becoming my close friends in later years. There were 13 in the American party which number was unfortunate for Barnard, Curtis, and others at Solok for they had clouds. (The details are given in the *Naval Observatory Publication* cited above.) Twenty-five miles away, with a plane grating spectrograph, focussed by Jewell, on account of his greater experience, I had clouds throughout the 5 min. 41 sec. of totality. Towards the end of totality, the clouds became thinner and I secured a photograph of the flash spectrum published in *The Astrophysical Journal,* **15**, 97, 1902, and in the *Naval Observatory Publication.*

For my third eclipse in Spain in 1905, I experienced the rare good luck in having many factors combine to furnish an excellent photograph of the flash spectrum. The skies were clear, the sun at high altitude brought good seeing conditions, long and careful preparation had brought good focus, and, moreover, the timing of the exposures had resulted in the photographs depicting low levels in the chromosphere of a few hundreds of kilometers above the photosphere. Four decades ago, comparatively little was known (compared with present-day information) regarding the laboratory spectra of the elements. Lockyer had already pointed out the greater strength of the enhanced lines in the chromosphere when compared with the Fraunhofer spectrum. But what were the enhanced lines other than that, for some reason then unknown, they had a greater intensity in the spark than in the arc spectrum? Lockyer's laboratory had published a few lists of these lines, but they gave only fragmentary information. For interpreting the flash spectrum, there was nothing to do but to draw one's own conclusions by slowly and painfully going to the published literature, by tabulating results and then deciding from the estimated intensities, frequently on different scales, just which lines were enhanced and which were not. It had been a great surprise that the H and K lines of calcium extended

to greater heights in the chromosphere than did the lightest of all elements, hydrogen. The published heights of my 1905 spectra furnished the means for the brilliant work of Saha. His theory of ionization, published a quarter century ago, has proven itself to be of very first rank importance for the science of astrophysics. Through greater accuracy in laboratory wave-length determinations and greater accuracy in the estimated intensities, largely through the observations of A. S. King at Mount Wilson, Meggers at the Bureau of Standards, Burns of Allegheny Observatory, and many others, order has gradually been brought out of chaos in our knowledge of laboratory spectra. This abundant material, in the skillful hands of Henry Norris Russell and Charlotte E. Moore, has finally resulted in the revised edition of "A Multiplet Table of Astrophysical Interest," 1945.

But to return to the gradual accumulation of knowledge of eclipse spectra. To further the information obtained in 1905, three concave gratings were set up in Oregon for the 1918 eclipse. The gratings were used without slit and they had radii of curvature of 21 feet, 10 feet, and one meter, respectively. The records of the U. S. Weather Bureau promised clear skies, but alas! Second contact was observed through thin clouds, but during the progress of totality of 112 seconds conditions vastly improved so that at the end of totality only a thin haze covered the sun. Two minutes after the total phase was over, the sun had reached a blue patch of sky! The developed photographs of the flash spectrum showed spectra in good focus but only the stronger lines had got through the haze to delineate themselves. The clouds that played such havoc with photographs of the chromospheric spectrum unquestionably added great beauty to the gorgeous spectacle that greeted the eye during totality. The 1918 eclipse was a phenomenon of brilliant color, with the "eagle" prominence immediately above the dark moon, while in the lower right-hand quadrant was the enormous prominence which was dubbed the "heliosaurus." The most interesting novelty at this eclipse was actually planned so that it might become the frontispiece illustration of the first edition of the writer's "Eclipses of the Sun," Columbia University Press. When, a year before the eclipse, the plan was unfolded to my good friend, Edward D. Adams, he took an enthusiastic interest. He and Howard Russell Butler were in Oregon for a fortnight before eclipse day so that Mr. Butler might be thoroughly acquainted with the information the astronomer might impart to him. As everyone knows, the completed painting, 49x33½ inches, was a tremendous success. After going through all the preliminary stages with Mr. Butler, when I first saw the completed masterpiece in a darkened room at the American Museum of Natural History in New York City, I felt a great thrill and found myself back immediately in Baker, Oregon, watching again the gorgeous phenomenon and feasting my eyes at great length in contrast to the fleeting glances during the

course of a busy program at eclipse time. The original painting is the prized possession of the Hayden Planetarium in New York. It is one of a triptych of paintings by Mr. Butler that includes the two succeeding eclipses of 1923 and 1925. The painter was not far from me in the earlier of these two eclipses and was with me at the 1925 eclipse. The three paintings are reproduced in color in the 3rd and 4th editions of "Eclipses of the Sun," and copies of the paintings are in Philadelphia at the Fels Planetarium of the Franklin Institute and in Washington at the National Academy of Sciences building.

What a bitter disappointment was in store for those of us who tried to observe the 1923 eclipse in "beautiful sunny California!" Within the "memory of the oldest inhabitant," there had not been a single cloudy day in San Diego on the tenth day of September, and to make matters almost ideal, the total eclipse came at one hour after noon when the danger from sea-fog was reduced to a minimum. I had two stations for photographing the flash spectrum, one on Point Loma near the central line of totality, the other near the edge of the shadow path at Lakeside. I myself was at the latter station and for the fifth time in succession had seen the corona and the prominences, but unfortunately through high cirrus clouds. The photographic program was carried through exactly as if it had been clear, and the plates when developed revealed what was expected of them, namely, practically nothing.

At San Diego, on North Island, was an important station for U. S. Navy airplanes. And hence it was planned to have the Navy attempt to photograph from the air in order, if possible, to determine the position of the edge of the moon's shadow. Unfortunately, on account of the high clouds, nothing worthwhile was obtained. In passing, it might be mentioned that after the eclipse was all over, the Navy had a grand aerial review for the Admiral of the Fleet and the then unprecedented number of 42 planes took part in the review and were in formation over North Island!

With such a fizzle in 1923, when conditions seemed so very promising, it seemed almost foolhardy to try to observe an eclipse which was to take place at nine o'clock of a winter's morning on the Atlantic Coast in the United States with the sun at best only eighteen degrees above the horizon. But no astronomer should ever attempt to observe an eclipse who is not fundamentally an optimist, a good gambler, if you will, prepared to take long chances. The McCormick Observatory expedition went to Middletown, Connecticut, in order to take advantage of the facilites afforded by the Van Vleck Observatory where my close friend, Frederick Slocum, was director. The spectrographs were installed in a temporary shelter just east of the dome. The weather was again a great surprise for us in 1925. It had been clear all through the preceding day and night but on eclipse morning dense clouds were everywhere at sunrise. The clouds persisted and still persisted, and even

up to five minutes before totality a cloud, very thin and very fleecy, hung over the sun. When the timers called out "two minutes." the cloud was still there, but one minute later, the atmospheric conditions appeared almost perfect, the thin cloud had gone! In spite of the bitter winter temperature of —15° C, successful photographs were obtained of the flash spectrum with two concave gratings, each used without slit.

If it was foolhardy to try and observe a winter's eclipse, even though comparatively near at home, was it not the height of folly to go to Norway for a 34-second totality on June 29, 1927? Those who have tried to go to the North Cape, to the land of the midnight sun, have learned, frequently to their sorrow, that fog is apt to be met, especially at the early hour of 5:34 of the morning that brought totality to Fagernes. However, it seemed most important that a record should be made of this eclipse, and of course for the investigation of the flash spectrum, the short duration of totality was no impediment. The popular enthusiasm in England was unbounded. There had not been a total eclipse for more than two centuries, and here was the chance to witness the wonderful phenomenon at a fine season of the year. On eclipse day, throughout England and Norway, the sky was heavily overcast but with a clear spot here and there. Only a miracle could save the situation, and such a miracle did actually take place in England for Dyson and the Greenwich expedition at Giggleswich and for Schorr and the party from the Hamburger Observatory at Jokkmokk in Scandanavia. Fortunately, Pannekoek and Minnaert, Vegard, and Baade secured photographs of the flash spectrum. For those who are interested in numerology, it might be added that my third eclipse was wonderfully successful, while for my seventh eclipse I was so unsuccessful that for the first time in my expeditions I failed to see the corona. There was nothing to do but to pack up, then make a trip to the land of the midnight sun, when we had perfect weather, and then go home and prepare for the next eclipse.

The October, 1930, eclipse meant a long trip of two-fifths around the world to an isolated island at 15° south latitude and not far from the international date-line. As a matter of fact, in the 8,000 miles of passage across the waters of the wide Pacific, the volcanic island of Niuafoou, or "Tin-Can Island," was the only available spot for observations. Fortunately, the U. S. Navy again participated, and officers and sailors were ashore for a period of ten weeks preparing for a 93-second totality. As everyone knows, in the tropics there are usually many clouds. Totality was to occur at 8:51 in the morning. When we got up at sunrise, to make matters as bad as possible, there was a slight drizzle. At first contact, the clouds were heavy, but as time advanced there seemed a perceptible thinning of the clouds. Would this continue, or would it thicken up again and doom us to disappointment? Another miracle happened! Fifteen minutes before totality, the clouds had cleared away, and conditions were perfect throughout the whole of

totality, but a bare half-hour after the important photographs had been made, clouds again gathered and persisted for the balance of the day.

I used two concave grating spectrographs without slits in order to cover as great a range of wave lengths as possible and with a considerable overlap for the two spectra. The problem of developing the eclipse films (on heavy celluloid) needed careful manipulation. Fine volcanic dust was everywhere in the air, there was no running water, and in fact very little water at best since all water had to be transported by the Navy. Daytime temperatures and a temporary dark room were formidable obstacles. With ice furnished by the Navy, and carrying development throughout the night, I was delighted to find the films in wonderful condition.

The successful spectra, with a dispersion 10.8 A per mm, covering a range in wave lengths from 3200 A to 7800 A were utilized to publish, "The spectrum of the Corona," in *The Astrophysical Journal*, **75**, 1, 1932. The results from the equally successful spectra of the chromosphere are now given publication for the first time. Following the eclipse, Mrs. Mitchell and I completed the three-fifth around the world, traveling *via* Australia and then Suez.

American astronomers in vast numbers observed the New England eclipse of 1932 August 31. I used the two grating spectrographs that I had had on Tin-Can Island. I crossed the international boundary into Canada and located the expedition near Magog alongside the party from Cambridge, England, under the direction of my friend Stratton. Unfortunately, throughout the whole path of totality, clouds were very wide spread. Indeed there were holes in the clouds here and there, just as in Norway in 1927, but not one of these holes was for us. For the second time in my eclipse career, I had failed to catch any glimpse of the corona!

Early in the year 1937, I was invited by the National Geographic Society to help organize and to become the scientific leader of the National Geographic Society-U. S. Navy expedition. This eclipse is memorable for the longest duration of totality in twelve hundred years (since the year 699). Two locations for the expedition were possible, namely, on one of the islands in the Phoenix Group near the international date line in 3° south latitude, and in Peru where totality occurred not far from sunset. With the assistance of the Navy, the expedition located on Canton Island, 1800 miles south of Honolulu. This is a coral atoll, then with no life on it except rats, hermit crabs, and thousands of sea birds. (Now the island is a very busy place with a large hotel, an important airplane station on the trip to New Zealand.) The expedition was on the island only half the time that we were on Niuafoou in 1930, twelve degrees farther south, and as a result there was a frantic rush to get ready. Needless to say, all equipment, all supplies, provisions and food had to be taken with us when we set sail from

Pearl Harbor. The activities of the expedition were well kept in the public eye through frequent radio talks, about twenty in number, of the National Broadcasting Company.

During the hectic days of preparation, the weather was very similar to that on Niuafoou in 1930, much of clouds but little rain. When the sun did shine, we had a double dose of its blistering heat, once direct, the other reflected from the coral underfoot. The great question was what would it be like on eclipse morning about an hour and a half after sunrise. As already has been said, an eclipse astronomer must be a confirmed optimist. A half hour before sunrise I had to talk over the radio. It was then cloudy as it was in 1930 under similar circumstances at Niuafoou. I must confess I had to lie like a trooper when I gave my confident opinion that a mircle would again happen. The miracle did actually take place. It was clear before first contact and for more than two solid hours thereafter only one isolated cloud covered the sun and that came nearly half an hour after the total phase of 3 minutes and 33 seconds had passed into history. The details of the 1937 expedition have been published in the *National Geographic Magazine* for September, 1937, and in the first number of the *Solar Eclipse Series of the National Geographic Society,* published in 1939.

Throughout my life as an eclipse observer I have experienced rare good luck. From my ten eclipses, I have secured measurable spectra at five different eclipses, in 1901, 1905, 1925, 1930, and 1937. In addition in 1918, a few of the stronger lines were photographed through the thick haze. Three times heretofore I have published wave lengths and associated data from my photographs of the flash spectrum. In each case, the original was published in *The Astrophysical Journal.* For the eclipses of 1901 and 1905, the discussions were elaborated and were printed in the *Publications of the U. S. Naval Observatory,* Second Series, Vols. IV and X. The spectra in 1905 were vastly superior to those at the earlier eclipse. The results appeared in *Ap. J.,* **38**, 407, 1913, and in *Publications of the Leander McCormick Observatory,* Vol. II, part 2. In the three decades since the appearance of these publications, there has been great and sustained activity among astrophysicists in investigations of the structure of the atom. At times the activities have been at feverish pitch. As already stated, the heights and intensities of the 1905 flash spectra furnished Saha the means for verifying his epoch-making theory of ionization. In various laboratories, but chiefly at the Mount Wilson Observatory, the electric furnace permitted spectra at different temperatures and with great dispersion. The accurate wave lengths and estimated intensities, in the hands of Henry Norris Russell and Charlotte E. Moore, permitted the intricacies of series relationships in multiplets to be gradually disentangled. This abundant material was assembled at Mount Wilson Observatory, and through the kindness of Director W. S. Adams all these splendid data

were placed at my disposal. Accordingly, I have made several visits to Pasadena during different summer seasons. With no teaching duties and with no astrometric researches from photographs taken with the 26-inch refractor, I could settle down and again become an astrophysicist. In several of my visits, Miss Moore was also in residence. She was always most generous in turning over for my use any and all of the multiplet material in her possession. Later, when she was located at the Princeton Observatory, she kindly sent by mail the discussions of the various elements as they became available. I am most grateful to Miss Moore for her continued kindness and generosity in turning over to me the spectroscopic material that was needed for the interpretation of the eclipse spectra.

The third discussion of the flash spectrum covered the eclipses of 1905 and 1925 together with 250 angstroms at the ultraviolet end from photographs at the eclipse of 1926 by Davidson and Stratton. Since the date of preparing this material for publication, I have been on three eclipse expeditions, on two of which, in 1930 and in 1937, I obtained successful photographs.

Three friends of mine, members of the American Philosophical Society, have been indefatigable eclipse observers. Their names are John A. Miller, for many long years one of the secretaries, Heber D. Curtis of the Lick, Allegheny, and University of Michigan Observatories, and W. W. Campbell, formerly vice-president of the Society and president of the University of California. My ten expeditions have taken me away from home for a total of more than two years, while the trips over the face of the earth have carried me in latitude from 72° north to 38° south, together with 360° in longitude. In preparing the equipment for the observations, in studying, measuring, and discussing the photographs, I have spent an additional ten or dozen years, so that roughly one-third of my life as a research astronomer has been devoted to eclipses of the sun.

Through grants of funds from the Research Committee of the Society, I have recently had the efficient collaboration of Dr. Rupert Wildt. Early in 1947, there will appear in *The Astrophysical Journal* the details of two separate publications under the names of S. A. Mitchell and Rupert Wildt. The first of the two will include the details of 3450 lines from flash spectrum photographs of the four eclipses of 1905, 1925, 1930, and 1937. The second publication will discuss from the astrophysical standpoint what new information regarding the sun and its atmosphere, the chromosphere, has been obtained from the study of the eclipse photographs.

The two later eclipses of 1930 and 1937 added very materially to the results of the earlier eclipse work. For much of the region included, from 3066 A in the ultraviolet to 8863 A in the infrared, interesting comparisons were possible between the eclipses of the different years.

In preparing the observational material for publication, I would again like to express my high appreciation for the rare good luck that has continued to stay with me in chasing total eclipses hither and yon. Good fortune again was experienced in the appearance of "A Multiplet Table of Astrophysical Interest," by Charlotte E. Moore, Princeton Observatory, 1945. After the long-continued struggles, already alluded to in the foregoing, it was a great joy to have a publication from the highest authority in order to decide on the element both in photosphere and chromosphere corresponding to a particular wave length.

The spectrum of the chromosphere is a reversal of that of the photosphere but with striking differences in intensities caused by the fact that for the Fraunhofer spectrum the radiation from the sun's surface passes radially through the relatively cooler gases of the chromosphere while at the time of an eclipse the radiation takes place in a tangential direction. The intensity of radiation, both in the absorption and emission spectra, depend on the total numbers of atoms involved which become very much the greater in the tangential direction of radiation. Hence the heights in kilometers that atoms extend above the photosphere are of major interest and these heights have been furnished from the eclipse spectra included in the discussion. From a knowledge of these heights may also be derived the relative abundance of elements in the sun's atmosphere, the density distribution of the various elements, together with other information of astrophysical importance.

About Mirror-Making in Switzerland

By J. ROHR*

The art of mirror-making is by no means a completely unknown hobby amongst amateur astronomers in Switzerland. Several decades ago, Krudy ground and polished several mirrors at Luzern and Basel, inducing a few friends to do likewise. Krudy, author of one of the three small books about mirror-making, that exist in the German language, based his methods mainly upon orthodox English experience.

At the time of Krudy and his pupils, probably even not a dozen mirror-enthusiasts—scattered all over the country and mostly unknown to each other—ground quietly their mirrors. But amongst them stands out the lonely figure of Schaer at Geneva, who—with the most primitive equipment imaginable—polished and mounted a score of Newton- and Cassegrain-Systems up to the two well-known ones of 40 inches, that brought him fame. Schaer also fashioned the biggest mirror, found before the war in Europe, a great 53-inch, still awaiting its mounting now for more than 15 years.

*Member of the Astronomical Working-Group of Schaffhouse, Switzerland.

Mentioning comparatively recently formed groups of two or three ardent amateurs and skilled semi-professionals at Lausanne and Geneva —experimenting today with Schmidt-Cameras and doing research-work on modern photographic films—and including the veteran Meyer at Berne with about 20 mirrors up to 10 inches to his credit, fill up the picture of mirror-making activities in Switzerland until 1944.

In that year (December, 1944) the writer had the opportunity to talk about "the poor man's telescope" before the forum of the "Naturforschende Gesellschaft Schaffhausen," demonstrating methods and results on a normal 7-inch mirror. The discussion was based on experiences with different mirrors up to 11 inches and substantiated by extensive "mining" in Albert C. Ingalls "Amateur Telescope Making" (both volumes) in the years before and during the war. As a result of the popular paper delivered, we expected four, or at best five, amateurs sufficiently interested to start the adventure of grinding a mirror for their own use in a course of mirror-making—a project fostered by the society. Instead of four as anticipated, not less than 18 gentlemen subscribed in the first instance for the course in our small town of only 23,000 inhabitants!

Dividing the bunch of the new-comers in four weekly evening shifts, the course was concluded in March, 1946. Twenty-one mirrors were finished (mostly normal 6 inches), including three short-focus ones of 1:4, "Universal"-mounting à la Tombaugh (the tube carried under the arm of the observer), used as richest-starfield and sight-seeing instruments.

That first course was not terminated, when the necessity of a second course in our same locality became obvious. Not less than 13 new apprentices wished to be introduced to the fascinating hobby of the mirror-fraternity. At the time of writing, the course is already nearing its end. In this second course two 8 and 10½-inch Newtonians are being ground, besides the thirteen normal 6-inch mirrors of the beginners. Simultaneously experimenting work on a small Schmidt-Camera has been started by Mr. Egger, a leading member of the group, a graduate of the Swiss Technical High School at Zurich.

Thus, the mirror-making hobby has started like a disease in our little town of Schaffhausen. Already we are organizing—at the request of new-comers who cannot wait!—a *third* course, destined especially for school-teachers in the canton, *i.e.*, the neighborhood of the town. We hope—and work earnestly in that direction—that in the near future the school of every village in the country around Schaffhausen will eventually have its own 6 or 7-inch reflector, ground by the teacher himself and his older pupils, mounted securely, with the official sanction of the school authorities of the little community.

Our aim is twofold:

1. In order to secure for astronomy the solid and broad foundation so necessary in the cultural life of a people, we believe there is only one

efficient and really far-reaching way: by means of the elementary and secondary school direct to the youth! Do show boys and girls wonders of the heavens and do not only talk about them! And for this purpose stands the school-ground mirror, rigidly mounted on sound construction principles, and adapted to the means of the most modest school budget, alone and supreme.

2. School teachers in Swiss country villages—usually people with very regular working and leisure hours, educated and mostly interested in scientific matters—enjoy as a rule the best weather conditions, available for astronomical observations. Therefore, enlisting schoolmasters throughout the country as mirror-makers and star-enthusiasts is in the end gaining the people for astronomy and at the same time gaining valuable, well suited observers and faithful servants of science in the teachers themselves.

On May 12, 1946, calling the unknown "tyros" of Switzerland in the Periodical of the Astronomical Society of Switzerland, the first gathering of mirror-makers in Switzerland took place at Basel (by courtesy of the principal of the Basel State Observatory, Professor Dr. Niethammer, in the rooms of the Observatory itself). Thirty "old hands" and eager beginners from every part of Switzerland came together, discussing the proposing, as a start of cooperation, of the foundation of a Documentary-Centre at Lausanne (Dr. Gérard C. Savoy, 1 rue de la Gare, Lausanne) and a further centre at Schaffhausen, destined to supply beginners with complete sets to start on the attempt of a first 6-inch mirror.

With regard to mountings we have been very fortunate. Our first course in 1945 comprised five gifted constructors and research technicians of well-known steel works and research laboratories of our community. In the spirit of joyful cooperation and under the spell of youthful enthusiasm they worked out in the winter of 1945/46 a design and model of a parallactic mounting—based partly on Russell W. Porter's ideas—built in wood, a few ready-bought steel parts and different light alloy implements, extremely rigid, with smooth working movements and, for its refinements, remarkably cheap. We are happy to state, that a series of not less than twenty mountings of similar patterns are being built at this very time in Schaffhausen and we will be only too glad to show one day to our American "Tutors" and "Pathfinders" the results of our modest endeavors in a picture of the first big "battery" of our instruments.

Our broadly-founded astronomical working-group is still in the making. It goes so far as to anticipate in the future the erection of a very simple station of observation in the hills above the town, equipped with one or possibly two Schmidt-Cameras of our own make, several reflectors, etc., doing useful work in the hands of experienced observers.

We hope, that the day may come, when not only half a hundred re-

flectors are figured and extensively used in and around Schaffhausen, but that the mirror-making hobby, so happily and successfully started anew here, may spread throughout Switzerland and later on through half-ruined Europe, not only to allow us to do our share of observing duties in the benefit of science, but to help in a very humble way to the enlightenment and the better understanding of mankind. We all need it.

SCHAFFHAUSEN, SWITZERLAND, JULY, 1946.

Planetary Phenomena in 1947

NOTE: Greenwich Civil Time is used unless otherwise stated. To convert to Eastern Standard Time, subtract 5 hours, to Central Standard Time, 6 hours, etc. The data are drawn principally from the *American Ephemeris and Nautical Almanac*.

A general survey of the phenomena relating to the planets in 1947 is given here. Details will be added in "Planet Notes" from month to month.

ECLIPSES

This year there will be three eclipses, two of the sun and one of the moon. This is nearly the minimum number of eclipses possible in a year. There will always be two eclipses of the sun in a year, and there may be as many as five. There may be no eclipse of the moon and there may be as many as three. In addition to the number of eclipses being small this year, the eclipses themselves are of little interest to people living in the United States.

I. The first eclipse is a total eclipse of the sun on May 20. The path of totality begins in the Pacific Ocean off the coast of Chile, extends northeast across South America, then crosses the South Atlantic and ends just before reaching the east coast of Africa some distance north of Madagascar.

The circumstances of the eclipse are as follows:

			Longitude	Latitude
	d h m		° ′	° ′
Eclipse begins	May 20 11 10.8		+66 42	−29 44
Central Eclipse begins	20 12 9.4		+77 46	−36 30
Central Eclipse at local apparent noon	20 13 35.1		+24 40	− 1 58
Central Eclipse ends	20 15 25.3		−36 58	− 2 12
Eclipse ends	20 16 23.9		−24 51	+ 4 46

For those living on the path and for those who may travel to points on the path in eastern Brazil, conditions will be quite favorable. Totality will occur when the sun is near the meridian and will last for more than four minutes.

II. The second eclipse is a partial eclipse of the moon on June 3. This will be invisible in the United States, because it will occur while the moon is below the horizon in the longitude of the United States. The middle of the eclipse will occur about one o'clock, P.M., Central Standard Time. Even for the regions in which the eclipse will be visible, the partial eclipse will not arouse much interest.

III. The third eclipse is an annular eclipse of the sun on November 12. The path of the annular eclipse lies almost entirely over the Pacific Ocean. Starting south of the Aleutian Islands, it extends southeast across the equator, then slightly northeast and ends near the equator about midway between the east and west coasts of South America. At points on the South American mainland the eclipse

will occur just before sunset. It will be visible as a partial eclipse from certain parts of the United States. At Washington, D. C., for example, the magnitude of the eclipse will be .04, and at Mount Hamilton and Mount Wilson it will be .39.

The circumstances of the eclipse are as follows:

		Longitude	Latitude
	d h m	° ′	° ′
Eclipse begins	Nov. 12 17 13.9	+160 16	+33 36
Central eclipse begins	12 18 20.4	+172 59	+41 6
Central eclipse at local apparent noon	12 19 48.5	+121 5	+ 6 6
Central eclipse ends	12 21 50.0	+ 61 39	+ 0 34
Eclipse ends	12 22 56.5	+ 75 47	− 7 11

The Planets

Usually in this connection we have given a chart from which one could discover the relation of the several planets to the sun throughout the year. No such chart is available this year hence information which will serve the same purpose is given in tabular form. The table gives the right ascension and the declination of the sun and of each of the brighter planets for the first of each month. Anyone who understands the meaning of the coordinates given will readily be able to determine the configuration of the planets on the dates specified, and by interpolation on intervening dates. Such a person will remember that of two objects in the sky the one having the larger right ascension will necessarily lie to the east of the other. In other words, if at a given time the right ascension of a planet is greater than that of the sun, the planet will rise after sunrise, and hence be invisible in the morning. These circumstances will also cause it to set after sunset, and hence be visible as an evening star. The reverse will indicate morning stars. As for the scale indicating angular distance in the sky it is necessary to recall that six hours along the equator represent ninety degrees of arc, that is the length of an arc from the zenith to the horizon.

Since the planet Mercury is visible for only a few days around certain critical dates, the table giving data at intervals of a month is not detailed enough to discover these dates precisely. Consequently a smaller tabulation is given for the purpose of detecting this planet on the rather rare occasions when it is far enough from the sun to be visible. The times of visibility are those when this planet is at or near greatest elongation, east or west.

Greatest Elongation of Mercury from the Sun

Eastern (Evening Star)				Western (Morning Star)			
Date	Distance from Sun	Decl.	Mag.	Date	Distance from Sun	Decl.	Mag.
	° ′	° ′			° ′	° ′	
Feb. 21	18 7	− 3 0	−0.4	Apr. 5	27 48	− 6 52	+0.5
June 17	24 41	+23 0	+0.6	Aug. 3	19 21	+19 57	+0.3
Oct. 13	25 2	−18 39	+0.2	Nov. 22	19 44	−12 19	−0.3

Venus, the other inferior planet, is so brilliant as to attract attention to itself whenever it is in the position of evening or morning star.

		—Sun—	—Mercury—	—Venus—	—Mars—	—Jupiter—	—Saturn—	—Uranus—
Jan. 1	α	18h 42m3	17h 46m2	15h 40m6	18h 48m4	15h 12m8	8h 39m8	5h 11m9
	δ	−23° 5′4	−23° 51′1	−15° 30′0	−23° 51′4	−16° 53′1	+18° 57′2	+23° 4′5
Feb. 1	α	20h 55m0	21h 22m0	17h 36m6	20h 30m8	15h 31m7	8h 29m9	5h 7m8
	δ	−17° 23′6	−17° 27′4	−19° 54′9	−20° 0′4	−18° 0′6	+19° 36′8	+22° 59′8
Mar. 1	α	22h 44m5	23h 29m5	19h 47m4	21h 58m7	15h 41m1	8h 21m6	5h 6m7
	δ	− 7° 59′1	+ 0° 3′9	−19° 36′6	−13° 31′0	−18° 29′0	+20° 7′4	+22° 58′6
Apr. 1	α	0h 38m3	22h 59m7	22h 14m0	23h 30m3	15h 40m3	8h 17m5	5h 9m0
	δ	+ 4° 7′8	− 7° 39′7	−11° 32′9	− 4° 21′8	−18° 22′6	+20° 22′3	+23° 1′6
May 1	α	2h 29m5	1h 31m5	0h 28m5	0h 55m6	15h 29m2	8h 20m2	5h 14m2
	δ	+14° 45′2	+ 7° 22′3	+ 1° 17′0	+ 4° 57′4	−17° 42′7	+20° 14′1	+23° 7′6
June 1	α	4h 32m1	5h 47m9	2h 49m6	2h 23m8	15h 13m6	8h 29m3	5h 21m5
	δ	+21° 54′5	+25° 32′1	+14° 41′9	+13° 35′3	−16° 47′1	+19° 43′8	+23° 15′3
July 1	α	6h 36m3	7h 54m9	5h 20m0	3h 51m1	15h 3m5	8h 42m3	5h 29m2
	δ	+23° 11′1	+18° 36′5	+22° 35′8	+19° 48′4	−16° 12′7	+18° 57′4	+23° 21′9
Aug. 1	α	8h 41m3	7h 21m2	8h 4m0	5h 22m5	15h 3m5	8h 58m0	5h 36m4
	δ	+18° 17′7	+19° 39′1	+21° 6′9	+23° 13′5	−16° 21′1	+17° 57′1	+23° 27′0
Sept. 1	α	10h 37m6	10h 50m4	10h 37m0	6h 51m1	15h 14m5	9h 13m8	5h 41m4
	δ	+ 8° 40′6	+ 9° 9′2	+10° 13′9	+23° 25′9	−17° 12′6	+16° 51′8	+23° 30′0
Oct. 1	α	12h 25m6	13h 46m0	12h 54m5	8h 9m4	15h 33m3	9h 27m3	5h 43m3
	δ	− 2° 46′0	−12° 39′8	− 4° 36′5	+21° 8′3	−18° 28′0	+15° 53′5	+23° 31′2
Nov. 1	α	14h 21m4	15h 2m2	15h 22m4	9h 18m6	15h 58m7	9h 37m4	5h 41m7
	δ	−14° 5′3	−19° 7′6	−18° 28′3	+17° 20′2	−19° 53′2	+15° 10′3	+23° 31′1
Dec. 1	α	16h 24m7	15h 13m8	18h 1m7	10h 11m1	16h 26m5	9h 41m5	5h 37m3
	δ	−21° 38′4	−16° 14′5	−24° 35′6	+13° 42′8	−21° 7′3	+14° 56′1	+23° 29′3

The Planets in February, 1947

By LELAND E. CUNNINGHAM

NOTE: The time employed is Central Standard Time unless otherwise indicated. The phenomena have been chosen and described for the North American continent, and especially for the United States. The basic data have been taken principally from the *American Ephemeris and Nautical Almanac*.

Sun. During February the sun will continue its northward motion, and by the end of the month will be only 8 degrees south of the equator.

Moon. The phases of the moon will occur as follows:

Full Moon	February	5	10 A.M.
Last Quarter		12	4 P.M.
New Moon		20	8 P.M.
First Quarter		28	3 A.M.

Occultations of third magnitude stars will be visible throughout the United States on the evenings of February 2 and 3. The first evening ϵ Geminorum will be occulted at about 10 P.M.; the following evening κ Geminorum will be occulted about 7 P.M. These stars are bright enough to be observed easily despite the nearness to full moon.

Evening and Morning Stars. Venus and Jupiter will continue brilliant morning objects, although quite far apart in the sky. Mercury and Mars will be inconspicuous evening and morning stars, respectively, very close to the sun; the former may be seen for a few days near February 20. Saturn will remain near opposition.

Mercury. The eastward motion begun in December will continue until February 26, when the planet will appear stationary. Its eastward motion will be more rapid than that of the sun until February 20, at which time it will reach its greatest elongation east from the sun—some 18 degrees. Since it will be a few degrees north of the sun, it should be easily seen low in the western twilight for a few days near this date.

Venus. Near the end of January, Venus began its long task of overtaking the sun again. During February their relative positions will change very little; Venus will remain near western elongation, and thus a brilliant morning star.

Mars. Mars will be too close to the sun for observation, although it is slowly moving out into the morning sky.

Jupiter. Jupiter will be in Libra, and will reach quadrature with the sun on February 15. It will be an interesting telescopic object for early risers. The second in the series of monthly occultations begun in January, and extending through October, will occur on February 12, but will be visible only in low northern and southern latitudes. To observers in the United States Jupiter and the quarter moon will be very close together at moonrise late in the evening of February 12.

Saturn. Saturn will continue its slow retrograde motion in Cancer near the Beehive. Its northern declination and its position on the meridian in the late evening combine to make it an ideal telescopic object for leisurely study.

Uranus. Uranus will be stationary in the eastern part of Taurus.

Neptune. Neptune will have begun its slow retrograde motion in Virgo.

Students' Observatory, University of California, Berkeley,
December 16, 1946.

Occultation Predictions for February, 1947

(Taken from the *Amerian Ephemeris*)

Date 1947	Star	Mag.	IMMERSION Greenwich C.T.	IMMERSION *a*	IMMERSION *b*	IMMERSION Angle E from N	EMERSION Greenwich C.T.	EMERSION *a*	EMERSION *b*	EMERSION Angle E from N
			h m	m	m	°	h m	m	m	°
Occultations Visible in Longitude +72° 30′, Latitude +42° 30′										
Feb. 2	121 Taur	5.3	3 35.0	—1.3	—2.9	131	4 26.1	—1.7	+1.2	220
3	ε Gemi	3.2	4 42.3	—1.3	—1.5	111	5 50.1	—1.2	—0.8	261
4	κ Gemi	3.7	1 30.9	—1.6	—0.2	115	2 41.0	—1.8	+1.1	254
8	ν Virg	4.2	4 32.9	—1.3	+0.5	108	5 44.1	—1.2	—1.0	316
10	65 Virg	5.9	4 21.3	—0.6	+1.4	92	5 19.1	—0.4	—0.9	331
10	66 Virg	5.8	5 7.5	—0.9	+0.9	104	6 13.7	—0.8	—0.7	323
10	72 Virg	6.1	9 56.4	—1.0	—1.9	152	11 7.4	—1.7	—1.2	278
12	ν Libr	5.3	10 37.5	—3.0	+0.6	71	11 34.5	—0.8	—2.4	349
13	λ Libr	5.1	9 16.8	—1.4	+0.2	117	10 41.2	—1.7	—0.4	300
16	86 B.Sgtr	6.5	10 55.2	0.0	—1.2	159	11 37.3	—2.8	+2.7	220
28	ω Taur	4.8	4 7.3	+0.5	—3.5	139	4 37.7	—0.8	+1.2	203
28	53 Taur	5.4	5 14.6	—1.4	+3.1	8	5 29.6	..	..	336
Occultations Visible in Longitude +91° 0′, Latitude +40° 0′										
Feb. 2	121 Taur	5.3	3 11.0	..	..	146	3 43.8	..	..	195
2	132 Taur	5.0	9 19.6	—0.5	+0.1	43	9 53.8	+0.8	—2.2	320
3	ε Gemi	3.2	4 18.1	—1.8	—2.2	131	5 19.0	—2.1	+1.2	234
4	κ Gemi	3.7	1 5.0	—1.1	+0.5	109	2 9.6	—1.2	+1.6	252
8	ν Virg	4.2	4 15.1	—0.6	0.0	126	5 21.9	—1.1	+0.4	290
10	ι Virg	4.8	10 0.8	—2.4	—0.1	95	11 10.7	—0.9	—2.2	340
12	ν Libr	5.3	9 54.2	—1.6	+0.2	111	11 16.6	—1.5	—1.0	315
13	λ Libr	5.1	9 3.3	—0.1	—0.8	154	10 6.0	—2.0	+1.3	265
28	53 Taur	5.4	4 59.1	—0.7	0.0	50	5 49.5	+0.2	—1.8	293
Occultations Visible in Longitude +120° 0′, Latitude +36° 0′										
Feb. 2	121 Taur	5.3	2 1.7	—2.0	—0.2	116	2 55.1	—0.8	+3.1	210
2	132 Taur	5.0	9 6.2	—0.7	—1.2	94	10 7.5	—0.3	—1.0	270
3	ε Gemi	3.2	3 22.4	—2.2	—1.1	130	4 14.3	—1.2	+3.4	217
3	37 Gemi	5.8	9 14.7	—1.7	+0.2	60	10 5.3	—0.1	—2.6	319
4	κ Gemi	3.7	0 46.9	0.0	+1.1	86	1 42.6	—0.3	+1.1	269
10	ι Virg	4.8	9 22.5	—0.5	—1.5	157	10 28.7	—2.2	+0.5	276
12	ν Libr	5.3	9 40.6	+0.6	—2.4	177	10 22.2	—2.3	+2.7	248
28	53 Taur	5.4	4 29.7	—1.6	—0.6	82	5 42.5	—1.0	—0.5	254
Occultations Visible in Longitude +98° 0′, Latitude +30° 0′*										
Feb. 1	247 B.Taur	57	0 44.3	..	..	357	1 12.4	..	..	314
2	132 Taur	50	9 21.4	—0.1	—0.7	84	10 13.2	+0.4	—1.0	281
3	37 Gemi	5.8	9 45.5	—1.6	+1.4	38	10 10.8	+1.3	—3.5	343
3	176 B.Gemi	6.3	22 32.5	—0.2	—0.2	129	23 10.6	+0.6	+2.1	225
4	κ Gemi	3.7	0 57.5	—1.5	—1.0	138	1 40.3	—0.3	+3.2	219
8	ν Virg	4.2	4 22.2	—0.5	—3.0	171	4 59.1	—1.3	+3.2	241
10	66 Virg	5.8	5 6.0	+0.2	—2.5	172	5 42.3	—0.9	+2.7	246
10	*l* Virg	4.8	9 53.1	—1.6	—1.3	134	11 19.4	—1.9	—1.5	306
12	ν Libr	5.3	9 51.3	—0.7	—1.4	151	11 8.3	—2.6	0.0	280
28	53 Taur	5.4	4 59.6	—0.6	—1.0	91	6 0.5	—0.3	—0.4	253

*Computed by Edgar W. Wollard and Paul Herget; communicated by Commodore J. F. Hellweg, Superintendent U. S. Naval Observatory.

The quantities in the columns *a* and *b* are given for the purpose of making these predictions useful for any place within 200 miles of the point indicated. The procedure is as follows: Subtract the longitude of the point given from the longitude of the place in question; multiply the result in degrees, taking the signs into account, by the quantity under *a* for the star to be observed; similarly, with the latitude, using *b*; apply the sum of the products, with its proper sign, to the Greenwich C.T., and obtain the predicted Greenwich Civil Time for the phenomenon at the place of observation. To obtain Eastern Standard Time it is necessary to subtract five hours; Central Standard Time, six hours, etc.

METEORS AND METEORITES

Meteor Notes from the American Meteor Society

By CHARLES P. OLIVIER, President

We welcome the following new members who have joined since the last list was printed on page 248, Vol. LIV of POPULAR ASTRONOMY:

Troop 16, B.A.S., 1011 Lake St., Oak Park, Ill.
Hirsch, Donald, 235 W. 76, New York 23, N. Y.
Mallett, C. R., 1200 Lexington Ave., New York 28, N. Y.
Assoc. of Amateur Observers, American Museum, New York, N. Y.
Wheeler, G. I., 805 Custer St., Laramie, Wyo.
Fisher, David, 201 E. University Parkway, Baltimore 18, Md.
Morrison, Miss Joyce, 730 Ridgeway Rd., Maplewood, N. J.
Kowalk, Miss Marie, 540 Concord Ave., New York 57, N. Y.
Bogard, Rev. David, 28 Ridge Ave., Little Falls, N. J.
Johnson, Alan P., 87 Woodside Ave., Amherst, Mass.
Arnold, F. L., 429 E. 22, Brooklyn 26, N. Y.
Gottwald, David, 2514 Knoxville Ave., Peoria, Ill.
Carter, John, 1327 Forest Court, Ann Arbor, Mich.
Bonnell, J. E., Box 661, Hooks, Tex.
Swanson, Miss G. F., R.F.D. 8, Box 707, Wichita 15, Kans.
Rutkowski, Ed., 37 7 Ave., Whitehead Manor, Trenton R.D. 4, N. J.
Keller, Ernie, 2106 15 Ave. S., Nashville, Tenn.
Reese, O. W., 1354 Belmont Ave., Youngstown, Ohio.
Folk, E. L., 119 Broad St., Salem, Va.
Fortuno, C. R., 1511 Lopez Landron St., Santurce, P. R.
Brooks, E. M., 3621 Olive St., St. Louis 8, Mo.
Cain, C. V., 2215½ 31 Ave. S., Minneapolis 6, Minn.
Buscombe, Wm., Univ. of Saskatchewan, Saskatoon, Sask., Can.
Wright, M. G., 927 S. Buckeye St., Kokomo, Ind.
Christoff, J. A., 600 E. Hatton St., Pensacola, Fla.
Scott, Tommy, Route 3, Nauvoo, Ala.
Astr. Soc. Stuyvesent H.S., 345 E. 15, New York 3, N. Y.
Sickman, Wm., 4 Woodland Ave., Batavia, Ill.
van Klecke, E. Stc., 4627 Warrent St. N.W., Washington 16, D. C.
Swift, A. R., 325 N. J. St., Lake Worth, Fla.

Mr. Vincent Anyzeski, 400 Lombard St., New Haven, Conn., has been reappointed to his former office of Regional Director for the New England States, except Maine. He has returned recently from several years of service in the United States Army. Mr. J. J. Neale, 29 Fairmont Ave., New Haven, Conn., who has been acting very efficiently for us during Mr. Anyzeski's absence, is appointed Assistant Regional Director for the same area. With the increased interest in

meteoric astronomy there should be more than enough routine work and planning to keep both of these active observers quite busy. I urge all our members in the five states concerned to keep in touch with their local headquarters, especially in promptly reporting any very brilliant fireball so that the papers can be asked without delay to publish requests for observations.

In Memoriam.—Belated news has reached me recently of the death in action of one of our members, Lieut. Sherwood T. Eriksson, U. S. Air Corps, 21 Bomber Command. He had been awarded the Air Medal and twice the Purple Heart. He was killed when his plane crashed at sea on May 3, 1945, after his seventh bombing raid over Japan in less than two months. Our Society has lost a valuable member, one in whose record we can take just pride, and our country, a brave, Christian soldier.

Recently also we have learned with great regret of the death of Dr. Wm. L. Holt, who has been a member for several years. While he was best known for his excellent work in the A.A.V.S.O., still he found time to cooperate effectively with us in various way, and our Society has sustained a real loss in his death.

The latter part of these Notes is a continuation of the data on the Draconid shower of October 9. Already articles dealing with the results are appearing elsewhere, quite the most valuable ones I have seen being those in *T.O.B.* No. 179 and the *Griffith Observer* for November. For myself, it continues to seem wise to publish the data in my hands first and then attempt to draw final conclusions, even if some of interest might be given at once. However, as to what was visible from the Southern Hemisphere, a letter from one of our active members, Mr. J. Fraser Paterson of Broken Hill, Australia, states that he observed from 1845 hours to 2230 hours on October 9, visibility being perfect (he too had the brilliant moonlight ∴ with $F = 0.4$ at best) and did not see a single meteor. Astronomical friends writing him from Adelaide and Melbourne confirmed the total absence of meteors. Of course we know from reports in this country that the actual shower lasted only a few hours, while there had been good reason to think that meteors from the radiant would appear for at least half a day before and half a day after the maximum. It was daylight in Australia during the critical hours. Also even when passing the meridian the radiant would have been very low in the north for that continent.

The following from the *Hydrographic Bulletin, U.S.N.*, indicates what the shower was in the eastern Atlantic: Second Officer H. J. Williams, *Am. S. S. Rainer* . . . "October 10, beginning at 0355 G.C.T. in latitude 40° 18′, longitude 19° 00′, 15 small meteors were observed in . . . 5 minutes . . . appeared in N . . . in next 30 minutes 20 more meteors were observer traveling in a similar direction . . . sky . . . clear . . . visibility good. . ." This was the very time when the shower was near maximum in the central United States. It is very surprising that more meteors were not seen from this ship, situated in about the same latitude. Reports on the shower from ships at sea have so far been singularly few, but we hope that more will come. We are fortunate, however, in just having received from Captain Guy V. Clark, Superintendent of the U. S. Naval Observatory, copies of the observations sent in from various naval stations, particularly in the Pacific. These will be published in "Meteor Notes" in due time. The cooperation of both the Naval Observatory and the Hydrographic Office, U.S.N., for many years past has been invaluable to the A.M.S.

Station and Observer	Direction	Began	Ended	Max.	Min.	Met.	Fac.	Rate Unc.	Obs.
Florida									
Bay Pines EST									
McNeill, W. S.	N-SW	9:00		10:30		x	0.4	x	1
								(6000)	1
Clearwater									
Skinner, B. C.		10:41	10:50		9¼	120	0.4	778	..
Enterprise									
Lynom, Mrs. W. A.		9:00	10:30		90	54		36	1
Fort McCoy									
Lisk, Miss H.		8:55	11:17	10:58	142	1000	0.4	455	2
								(820)	2
Gulf Breeze									
Battson, L. K.	N	8:15	10:15	10:	120	817	0.4	408	1
								(526)	1
Jacksonville									
Russell, G. O.		8:20	11:10	10:38	170	3121	0.3	1103	?
								(10,800)	?
Fordham, J. L.	W, N	6:30	11:00	10:49	135	741	0.3	329	1
								(10,800)	1
Barnett, W.	NW	9:30	11:00	10:45	86	688	0.3	275	1
								(1224)	1
Benton, J.	NW	9:00	10:55	10:50	20	223	0.3	669	1
								(1194)	1
Lake Worth EST									
Swift, A.	NW	9:30	10:00		30	57		x	1
Ocala									
Beeman, W. E.		9:45	11:30		105	800		457	2
Orlando EST									
Medsger, O. P.		10:20	10:50	10:42	25	437	0.2	1049	2
								(1240)	2
Pensacola CST									
Christoff, J.		8:30	10:30	9:45	120	1502		751	3
								(1228)	3
Ballon, E. G.		8:20	10:20	9:56		1218		923	1
								x	1
Sarasota									
Griffith, Miss J.	N	9:45	10:53		108	60		m	1
West Palm Beach EST									
Greenberg, G.		8:00	11:33	10:51	188	2024	0.4	643	3
								(3000)	3
Meosenhelder, Capt. R. J.	N	9:21	10:18		28	164			2
Tallahasse									
Thigpen, M.		7:30	11:30			965			1
Georgia									
Griffin EST									
Parker, P. O.		7:30	13:00	?		345	0.2		1
Macon									
Wilcox, Miss S.		10:15	11:31			345	0.3		5
Idaho									
Lewiston PST									
Bateman, R. E.	all	7:05	7:15		10	340	0.2	2040	3
Buhl MST									
Sandmeyer, Miss E.		7:35	10:35	7:52	80	1022	0.2		1
								(1036)	1

Station and Observer	Direction	Began	Ended	Max.	Min.	Met.	Fac.	Rate Unc.	Obs.
Illinois									
Chicago CST									
Millar, M.		8:15	9:32	9:17	75	243	0.2	194	1
Riley, W. B.	Z	8:20	10:30	9:52		383	0.2	177	1
Hay, A. A.	Z	8:25	11:00	9:52		268	0.2		1
								(528)	1
Welker, F.	Z	8:00	11:00	9:52		318	0.2		1
								(528)	1
Braitberg, H.	Z	10:00	11:00		60	26	0.1		1
Hay, A. A.	Z	7:00	8:00		60	130	0.2	130	2
F. W. Parker School	all	7:50	10:30	10:±		2175	0.1		28
Brunner, R. R.	E, NW	8:00	10:35	9:40	155	323	0.2	(468)	1
Callum, Wm.	Z	9:50	10:05		15	31			1
Elgin									
Sickman, W.	N	9:45	10:11		26	60	0.1		1
Berwyn									
Novak, Miss J.		8:40	9:10		30	107	0.2	204	2
Champaign									
Tapscott, C.	NW	9:03	10:21	9:38	72	1525	0.3	1271	1
								(2040)	1
Decatur									
Bone, M. E.	N	9:05	9:15		10	81	0.2	486	1
Heiland, K.	NW	9:27	9:44		15	203	0.2	812	1
Marquis, D.	NNW	7:30	7:40		10	65	0.4	390	1
Noll, Miss A.	W	8:00	8:30		30	29	0.4	58	1
Kalipe, Miss H.	S	6:30	9:30		180	350	0.2	117	1
Lawton, S.	N	8:30	8:50		20	63	0.4	189	1
Lowe, Miss J.	NW, NE	7:49	9:15		20	123	0.2	369	1
Downs									
Haseltine, E.		7:30	10:00	9:45	150	2353	0.3	941	6
								(2006)	6
Homeward									
Astronomy Club		8:30	10:00		90	49	?		?
Joliet									
Preucil, F.		7:55	10:10	9:40	120	877	0.1		1
							0.2	(797)	1
Brodeske, J.		7:45	10:00		120	899	0.2		1
Cooke, R.		7:45	10:00		120	625	0.2		1
Grose, H.		7:45	10:00		120	125	0.2		1
Price, R.		7:45	10:00		120	675	0.2		1
Wilson, B. H.		7:45	10:00		120	795	0.2		1
Shaw, E. C.		9:00	10:00		60	507	0.2	507	1
Younghusband, H.		9:30	9:42		12	108	0.2	540	1
Mattoon CST									
Fischer, J. T.		9:	9:10		10	40	0.3		1
								(480)	1
Mooseheart									
B. S. Troop 30	NW	9:30	10:		?	15	0.1		?
Oak Park									
Turner, Miss H. S.	all	7:15	10:15			473	0.2		8
"		7:02	8:50			107			3
Peoria									
Norman, H. V.	NW	9:30	10:00		20	194	0.2	582	1
Shelbyville									
Wilch, A.	NW	7:53	9:33		100	200	0.2	120	1
Skokie									
Young, J.	SE	8:10	9:45		95	150	0.1	95	1
Urbana									
Paine, E. B.		8:00	10:30	9:55		690	0.4		1
								(1200)	1

Station and Observer	Direction	Began	Ended	Max.	Min.	Met.	Fac.	Rate Unc.	Obs.
Illinois									
Urbana									
Armagert, Mrs. J. W.		10:00	10:30		30	1800±		3600	2
Waukegan									
Kirk, Miss D.	SE	8:40	9:30			20			1
Normal									
Ill. Soldiers and Sailors School		7:30	9:02	8:54		7020	0.2		40
								(972)	5
Indiana									
Batesville CST									
Wesler, Miss R.		8:10	9:35	9:25	80	446		334	*1
								(639)	
East Chicago									
Foley, G. C.	SW	6:30	7:30		60	27		27	1
Indianapolis									
Hopkins, T. E.	N	8:45	11:12	9:54	89	510	0.4	345	1
								(870)	1
Jeffersonville									
Hall, G.	N	9:41	9:51		10	202	0.4	1212	1
Seymour CST									
Frey, G. C.		8:00	11:00	9:45	180	1778		593	1
								(1768)	1
Iowa									
Dysart CST									
Coe, A. C.	NW	9:00	10:00		60	800+	0.2	800+	2
Sibley CST									
Fitzsimmons, C. S.	NW	9:35	11:30	10:08	85	929	0.2	654	1
								(1388)	1
Kansas									
Anness									
Vulgamore, Miss O.	W	8:45	8:55		10	58	0.4	348	1
"	N	10:	10:10		10	152	0.4	912	1
Arnold									
Clews, Mrs. E.	NW	9:32	9:55		20	248	0.2	744	1
Burns									
Notz, Mrs. W.	NW	9:50	10:00		10	261	0.3	1566	1
Hutchinson									
Bolyard, E. J.	NW	9:30			10	105	0.2	630	1
Larned									
Simmons, E.	NW	8:15	10:			1000		571	2
Lenore									
Leidig, Mrs. K.	all	10:20	10:30		10	202	0.2	1212	5
Lost Springs									
Anderson, H. A.	N	10:45	11:15		10	138	0.4	828	1
Manhattan									
Raburn, G. E.	NW	7:15	8:54		54	94		104	1
Milan									
Birkholz, Mrs. W.	N	9:15	9:25		10	181	0.4	1086	1
North Newton									
Gingrich, O.	NW	8:00	11:00	9:30	180	2402	0.4	801	2
								(1842)	
Plainsville CST									
Meistrell, D. E.	N	9:30	9:40		10	79	0.2	474	1
Strong City									
Rogers, G. E.		10:15	10:25		10	33		198	1
Topeka CST									
Chappell, M.		9:45	9:55		10	135		810	*1
Sanders, Miss D.		9:45	9:55		10	101		606	1

Station and Observer	Direction	Began	Ended	Max.	Min.	Met.	Fac.	Rate Unc.	Obs.
Kansas									
Topeka									
Cunard, H.		9:45	9:55		10	102		612	1
Snyder, R. R.	NW	9:15	9:30		15	155	0.4	620	1
"		9:40	9:50		10	135	0.2	810	1
Wellington									
Thompson, Mrs. C.	N					42	0.1		1
Stoelzing, A. W.		8:00	10:15	9:52	135	559	0.2	248 (608)	1

*1+.

NOTES: In column 9 m indicates that the meteors were plotted. When rates are not given in this column it indicates that cloud conditions were so irregular or the intervals covered by observations gave such different rates that an average rate for the whole period would have little meaning. In all the columns only data actually in the original report, or easily derived therefrom, are given. This explains numerous empty spaces in the table. Some of the more valuable reports will receive further detailed analysis after all the résumés have been published.

Flower Observatory, Upper Darby, Pa., 1946 Dec. 6.

Contributions of The Meteoritical Society

(Known Formerly as The Society for Research on Meteorites)*

Edited by FREDERICK C. LEONARD

Department of Astronomy, University of California, Los Angeles 24

An Investigation of the Time Distribution of Meteoritic Falls by Years†

JOHN A. RUSSELL

Department of Astronomy, University of Southern California, Los Angeles

ABSTRACT

An attempt is made in this paper quantitatively to remove the systematic human factors from the annual counts of observed meteoritic falls from 1790 to 1939, inclusive. The probability that the fluctuations remaining in the counts are due solely to errors of sampling is then determined. These remaining fluctuations are shown to be normally distributed, to a close approximation, except for the years 1868 and 1933.

The important effect of the human element upon the number of observed meteoritic falls is obvious. The limited extent to which observers are scattered over the Earth's surface, however, and the large fraction of the actual falls that accordingly pass unnoticed are not so readily realized. These facts were empha-

*In accordance with the announcement in *C.S.R.M., P. A.*, **54**, 430, October, 1946, these CONTRIBUTIONS, beginning with the present (January, 1947) instalment, which opens Vol. 4, carry the new name of the Society, and are therefore entitled CONTRIBUTIONS OF THE METEORITICAL SOCIETY (to be abbreviated *C.M.S.*)—ED.

†Read at the Ninth Meeting of the Society, Flagstaff and Meteorite Crater, Arizona, 1946 September 9 and 10.

sized by Willard J. Fisher,[1] who showed that 0.6% of all observed falls have struck roofs or roads. The percentage of the landing space available for these extraterrestrial visitors represented by this area of roofs and roads, altho difficult to estimate, is notably less than 0.6%.

As early as 1819, E. F. F. Chladni[2] (sometimes called "the father of meteoritics") investigated the possibility of seasonal fluctuations in the number of observed falls. The data available to him were too meager to form the basis for a definite conclusion, but it was Chladni's opinion that, had there been an observed difference between summer and winter, the explanation was to be sought in the fact that more people are out-of-doors in summer than in winter. This opinion has received ample substantiation in the investigation of Fisher, already referred to.

Among the important conditions that favor the observation of a meteoritic fall, according to Fisher, are the following:

1. A uniform scattering of observers such as exists in areas where small-scale agriculture is prevalent.

2. The necessity for the population to be abroad frequently and extensively in the performance of their daily routines.

3. Fine weather.

4. Long days.

5. The location of the antapex of the Earth's orbital motion above the horizon.

6. A high degree of enlightenment of the population concerning meteoritical phenomena.

If the number of observed falls be considered as a function of the time expressed in a given unit, all of the conditions in the preceding list will not apply. Possible time units and the conditions specially favoring systematic differences in the number of observed falls during these units may be tabulated as follows:

Time Unit	*Conditions Favoring a Departure from Random Distribution*
Hour	2, 5
Day	3, 4, 5
Month	3, 4, 5
Year	1, 6

After a consideration of the influence of these factors on the number of observed falls, Fisher[1] concluded:

"The forms, then, of the annual [by months] and diurnal [by hours] frequency graphs agree fairly well with the hypothesis that the frequency of observed meteorite falls is determined by the conditions of easy penetration of the atmosphere [condition 5], easy visibility of the phenomena, and the wide and uniform distribution of observers." In other words, it is not necessary, apparently, to assume anything but a random distribution of meteoritic material in the Earth's path, in order to explain qualitatively the variations in the observed numbers of falls by hours and by months.

Altho O. C. Farrington[3] noticed that the number of falls observed in the decade 1860-70 considerably exceeded those observed in either of the 2 succeeding decades, regarding the observed falls by years he stated:

"This record on the whole seems to indicate a comparatively uniform supply

of meteorites, which is the more remarkable when one considers the various chances affecting the observation of their fall."

In an effort to arrive at a conclusion more definite than Farrington's, in regard to the uniformity of meteoritic falls by years, an attempt is made in this paper quantitatively to remove the human factors from the annual counts; then the probability that the remaining fluctuations are due solely to chance differences in sampling and not to cosmic or other factors is considered. The source of the data used in this discussion is Table 1 of a paper by Frederick C. Leonard with Boris Slanin.[4] This table contains, to the best of my knowledge, the most complete compilation of the time distribution of observed meteoritic falls made to date.

In order to render the general trend of the counts more readily discernible, a block curve was drawn to show the number of observed falls per decade from 1790 to 1939, inclusive, the period covered by Leonard and Slanin in their study. An examination of Fig. 1 shows that the counts increase in an approximately

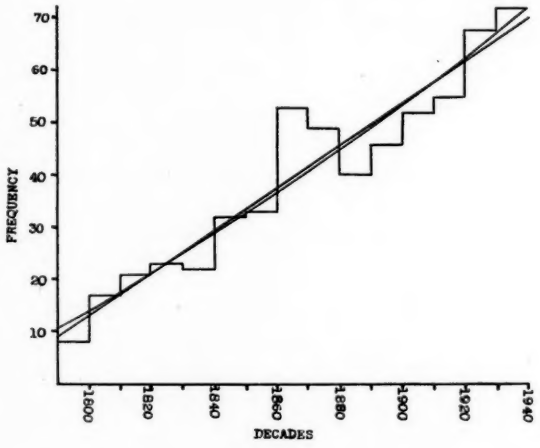

FIG. 1

THE FREQUENCY OF OBSERVED METEORITIC FALLS BY DECADES FROM 1790 TO 1940

linear fashion, except for the decade 1860-70. The assumption that this increase in the counts is real, *i.e.*, that it is due to the fall of an increasingly greater number of meteorites, leads to the conclusion that no falls were observed previous to 1765, and that, in less than 9 centuries hence, the observation of a meteoritic fall will become a daily occurrence somewhere on the Earth! In this discussion it will be assumed that this increase is due entirely to linear increases in the human factors that have already been listed as favoring a departure from random distribution in the number of observed falls by years.

A solution was made, on the basis of least squares, for the equation of the best straight line that will pass thru the block curve of Fig. 1. The equation of that line is:

$$N = 0.410t + 0.867, \quad (1)$$

where N is the average number of falls observed annually in a decade, and t is the number of decades since 1790. Residuals were formed by comparing the observed counts with values of N calculated with the aid of equation (1). For the purpose of comparison, the equation of the second-degree curve most closely fitting the data of Fig. 1 also was calculated by least squares. That equation is:

$$N = 0.00502t^2 + 0.337t + 1.025, \quad (2)$$

where N and t have the same meanings as in equation (1). A set of residuals was obtained by comparing the observed counts with those calculated by use of equation (2). The sum of those residuals, without regard to sign, was found to be 2.3% smaller than the similar sum of the residuals obtained by aid of equation (1). The size of the residual for the decade 1860-70 was, however, increased about 8% by using equation (2), and since this fact would render the possibility of explaining that large residual on the grounds of chance still more remote, it was felt that the use of equation (1) as a basis for the calculation of N represented the more conservative and preferable procedure.

TABLE 1

Residual in units of p.e.	f_o (Obsd.)	Prob. (Theory)	f (Theory)	$(f_o - f)^2/f$
Over 3.0	3	0.021	3.15	0.007
2.5 to 3.0	1	0.024	3.60	1.878
2.0 to 2.5	8	0.043	6.45	0.373
1.5 to 2.0	12	0.067	10.05	0.375
1.0 to 1.5	14	0.094	14.10	0.001
0.5 to 1.0	13	0.118	17.70	1.248
0.0 to 0.5	22	0.132	19.80	0.245
—0.5 to 0.0	20	0.132	19.80	0.002
—1.0 to —0.5	21	0.118	17.70	0.616
—1.5 to —1.0	13	0.094	14.10	0.086
—2.0 to —1.5	13	0.067	10.05	0.866
—2.5 to —2.0	6	0.043	6.45	0.031
—3.0 to —2.5	1	0.024	3.60	1.878
Under —3.0	3	0.021	3.15	0.007

From an enlarged plot of equation (1), a value of N was read for each of the 150 years from 1790 thru 1939. By comparing these values with the actual counts, a set of 150 residuals was obtained. The probable error of a single annual count, based on these residuals, is ± 1.2 falls per year. The residuals were grouped as shown in Table 1, in which the first column gives the residual size in units of the probable error; the second column contains the numbers of years for which the residuals fall into each of the intervals of the first column; the third column gives the probabilities (obtained from a table[5]) that a residual in a normal distribution will fall within each interval; and the fourth column lists the numbers of years that this theory predicts should fall within each interval (obtained by multiplying the figure in the third column by the total number of observed falls). The last (fifth) column contains figures, formed as indicated in the column heading, that were used in calculating the probability that the departures from normalcy of the observed distribution of annual residuals are due solely to chance.

The observed distribution of residuals is shown by the block curve in Fig. 2. For comparison, the theoretical normal distribution is shown by the smooth

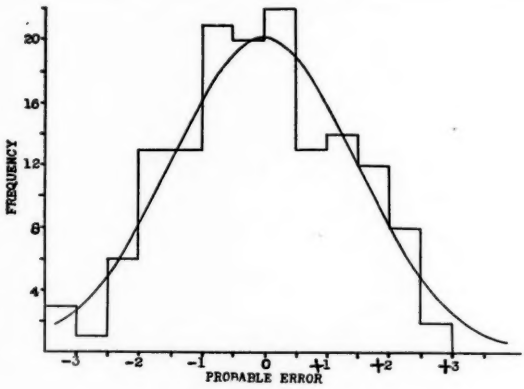

FIG. 2

THE OBSERVED AND THEORETICAL DISTRIBUTIONS OF RESIDUALS ($O-C$) IN UNITS OF THE PROBABLE ERROR FOR 150 COUNTS OF OBSERVED METEORITIC FALLS BY YEARS FROM 1790 TO 1940

curve. A quantitative measure of the goodness of fit is afforded by the so-called χ^2-test. The quantity χ^2 is, by definition, the summation of the values appearing in the fifth column of Table 1. A rather complex pair of equations, due to Karl Pearson,[6] relate χ^2 and the probability, P, that the divergence of the observed distribution from normalcy is due solely to errors of sampling, and the number of step-intervals, n, in the tabulation of the distribution. Values of P as a function of n and χ^2 have been tabulated, however, and afford a ready means for determining P.[7] The value of P in the distribution under consideration can be varied slightly by altering the number of groups or by throwing a border-line measure one way or the other, but this variation is only 0.01 or 0.02 on either side of 0.90. According to Henry E. Garrett,[8] P must be less than 0.02 before the distribution is considered to deviate significantly from the normal form.

The number of falls observed in 2 of the 150 years under consideration deserve special attention. In 1868 and in 1933, 11 and 15 falls, respectively, were observed. The residual for 1868 was 5.8 times the probable error of a single annual count. From a table such as that already referred to,[9] the probability of the occurrence of such a large residual can be determined in round numbers to be 1 in 10,000. From the law of compound probability of independent events,[10] it follows that, if the chance of such a large residual's not appearing in 1 trial is 9,999 out of 10,000, the chance of one's not appearing in 150 trials is $(9{,}999/10{,}000)^{150}$ or about 0.985. In other words, the chance that this residual could occur in 150 trials as a result of errors of sampling is about 1 in 70. The residual for 1933 is 6.9 times the probable error. The chance of this residual's occurring in 150 trials is only 1 in 1400. It is interesting to note the proximity of these 2 years of abnormally numerous falls to the years in which the 2 greatest meteoric showers of the last hundred years occurred, namely, the Leonid shower of 1866 and the Giacobinid (or Draconid) shower of 1933. It is interesting to note also—altho it is obviously of even less significance—that more authenticated

meteoritic falls were observed in the year that the Meteoritical Society (then known as the Society for Research on Meteorites) was founded than in any other year of recorded history!

On the basis of the foregoing results, the following summary may be given:

On the assumption of a linear increase in the effect of the human factors influencing the number of annually observed meteoritic falls, the probability that the scatter in the annual counts is due purely to chance fluctuations in sampling is about 0.9. There is a strong indication, however, that the number of falls observed in 1868 and in 1933 were due to factors others than mere chance fluctuations in sampling. It would appear either that the human factor has not been adequately removed from the data or that more potential fallen meteorites were actually encountered by the Earth in those 2 years than in any of the other years from 1790 thru 1939.

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[10] Holmes, Maurice C., *op. cit.*, ref. ([6]), *ante*, 6.

On the Probability of Coincidental Meteoritic Falls*

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Communicated by Frederick C. Leonard

ABSTRACT

By means of Poisson probabilities, the number of coincidental meteoritic falls in the United States is shown to be unreasonably large when the probabilities are based upon the density of total falls. Either some of the coincidental falls are not distinct falls or such factors as increased searching in the vicinity of known falls may account for the excess.

This paper was written at the suggestion of Professor Leonard, who felt that meteoriticists would be interested in a study of the probability that distinct falls of meteorites will possess the same coördinate number. If 2 or more falls have the same coördinate number, they will be said to constitute a coincidental fall. The method that will be employed to study the relative frequency of coincidental falls is to derive an upper bound for the probability that at least as

*Read at the Ninth Meeting of the Society.

many coincidental falls will occur as have been observed.

Let a given region R be divided into n subregions such that it may be assumed that the probability that a meteoritic fall will be found in a specified subregion is the same for all the subregions. In a region that does not possess numerous subregions devoid of population, such subregions might be selected as subregions of equal area. Then the probability that a meteoritic fall known to be in R will be found in a specified subregion will be $1/n$. If the subregions are subregions of equal area, this assumes that the falls are randomly distributed in R. Suppose, now, that there are k falls under consideration in R and that interest is centered on the probability that a certain number of these k falls will be found in a specified subregion. The k falls may be treated as k independent trials of an event for which the probability of success in a single trial is $1/n$. When the number of trials (k) is very large and the probability in a single trial ($1/n$) is very small, the probability of obtaining a specified number of falls (x) in a specified subregion is given to a high degree of accuracy by the Poisson function

$$\frac{e^{-m} \cdot m^{x}}{x!}, \tag{1}$$

where $m = k/n$ is the mean number of falls per subregion. In particular, the probability that a specified subregion will contain either 0 or 1 fall is obtained by letting $x = 0$ and $x = 1$ and adding. Thus,

$$e^{-m} + e^{-m} \cdot m$$

gives this probability. Consequently, the probability that a specified subregion will contain 2 or more falls is given by

$$p = 1 - e^{-m}(1 + m).$$

Now the n subregions may be treated as n independent trials of an event for which p is the probability of success in a single trial. Success here corresponds to obtaining a subregion possessing 2 or more falls. Since n is very large and p will be found to be very small, the probability of obtaining a specified number of subregions (x) having 2 or more falls each also will be given to a high degree of accuracy by a Poisson function

$$\frac{e^{-\mu} \cdot \mu^{x}}{x!}, \tag{2}$$

where $\mu = np$.

From (2) it follows immediately that the probability that at least r of the n subregions will possess 2 or more falls each is given to a high degree of accuracy by

$$P = \sum_{x=r}^{n} \frac{e^{-\mu} \cdot \mu^{x}}{x!}, \tag{3}$$

where $\mu = np$, $p = 1 - e^{-m}(1 + m)$, and $m = k/n$. Tables[1] are readily available for evaluating P when μ and r are given.

As an application of this formula, consider the probability of obtaining as

many coincidental falls in the United States as have been observed. From a recent catalog of meteoritic falls,[2] it was found that there are recorded 15 coincidental falls out of a total of 501 falls. Since a coördinate number extends over a slightly larger area in the Gulf States than farther north, the number of coördinate numbers in the United States will be underestimated if the area of the United States is divided by the area over which a Gulf-State coördinate number extends. The area of a rectangle 0°.1 on a side in latitude 30° is less than 43 square miles; consequently, since the area of the United States is about 2,970,000 square miles, the total number of such rectangles would be at least 69,000. Since a large percentage of the total area is seldom traversed by man, it is necessary to decrease this number by a factor that will enable it to represent more realistically the number of such rectangles in the United States in which meteoritic falls might be expected to be found. A comprehensive study of why meteorites are not found in certain types of regions and an estimate of the total area of such regions would be necessary to arrive at a reasonable estimate for a shinkage factor. As a conservative guess that is not based upon any such study, it will be assumed that the total number of admissible subregions of the size being discussed is at least 20,000. This guess, which assumes that only about 29% of the United States is sufficiently traversed to make the discovery of meteorites likely, will make the probability about to be computed too large and hence will make the resulting conclusion too conservative if a larger guess were more reasonable. If this estimate is used, calculations will give

$$
\begin{aligned}
&n = 20{,}000;\\
&m = k/n = 501/20{,}000 = 0.02505;\\
&p = 1 - e^{-m}\,(1+m) = 0.000308;\\
&\mu = np = 6.16.
\end{aligned}
\tag{4}
$$

Consequently, for 15 coincidental falls, (3) becomes

$$
P = \sum_{x=15}^{20{,}000} \frac{e^{-6.16}\,(6.16)^{x}}{x!}.
$$

The tables referred to previously[1] yield

$$P = 0.002.$$

Since this value was obtained with a value of m that is at least 3 times the recorded density of falls, it is highly improbable that as many coincidental falls should have occurred as have been recorded. Either some of the coincidental falls are not distinct falls or there are important factors that have been ignored in the preceding theory to account for the excess of coincidental falls.

The most important factor that might give rise to a larger number of coincidental falls than is justified by the foregoing theory is the increased amount of searching taking place in the vicinity of known falls as contrasted with that in subregions for which no falls have been recorded. If only those subregions are considered in which 1 or 2 falls have been recorded, then it is possible to use the relative frequency of such subregions to estimate the mean density of falls

(m) for the region consisting of the totality of such subregions.

Let n_1 and n_2 denote the number of single- and double-fall subregions, respectively, in a region R. If R is made up of n subregions, then from (1) the expected number (E) of single- and double-fall subregions will be given by

$$E(n_1) = n e^{-m} m$$

and

$$E(n_2) = n[(e^{-m} m^2)/2].$$

The value of m may be expressed in terms of the expected numbers by dividing the second equation by the first to give

$$m = 2[E(n_2)/E(n_1)]. \tag{5}$$

An estimate of m that will be fairly reliable if n_1 and n_2 are not small may therefore be obtained by replacing the expected numbers in (5) by their observed values. Thus,

$$m' = 2(n_2/n_1) \tag{6}$$

gives the desired estimate.

As an illustration, consider the application of (6) to the United States. Since $n_1 = 471$ and $n_2 = 15$ here, $m' = 0.064$. This estimate of m is nearly 3 times as large as the estimate that was used in (4) for calculating the probability of coincidental falls and nearly 9 times the recorded density for the entire United States. Hence, it would be necessary to assume that increased searching in the vicinity of known falls is sufficient to raise the density of recorded falls in such regions to nearly 9 times the density for a subregion selected at random in the United States before the first alternative could be discarded, namely, that not all of the recorded coincidental falls in the United States represent distinct falls.

As a second illustration, consider the application of (6) to Chile. Here $n_1 = 29$, $n_2 = 5$, and $m' = 0.345$. Since the recorded density of falls for Chile is less than that for the United States, and this estimate is more than 5 times the corresponding estimate for the United States, this large value of m' seems highly unreasonable. In this computation, 9 falls that are customarily considered as the same fall were treated as distinct; hence the resulting estimate is overly conservative. Unless there are valid reasons for expecting much more thoro searching for other falls in the vicinity of known falls in Chile than in the United States, several of the Chilean coincidental falls undoubtedly do not represent distinct falls.

In applying the preceding formulas to different countries or regions, it is not possible to determine which of the 2 proposed alternatives is the more reasonable explanation of coincidental falls unless a study is made of how the second fall of each coincidental fall was discovered. This paper is not concerned with such studies or with other alternatives that could be proposed.

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Note on a Supposed Meteorite Crater in North Africa

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In a note entitled "A Possible New Meteorite Crater in North Africa" (*C.S.R.M.*, **3**, 72; *P. A.*, **51**, 96, 1943), H. H. Nininger has described a "peculiar crater" in "15° 06′ N. Lat. and 26° 15′ E. Long.," seen by Mr. Orval M. Klose on or before July 21, 1942, and photographed by him and Captain E. B. Fricks sometime between that date and November 23, 1942. Klose's comments and the photographs submitted by him gave Nininger the impression that "the crater's structure lends itself to a meteoritic interpretation." However, in *Mineralogical Abstracts*, **8**, No. 11, 378, 1943, Dr. L. J. Spencer points out that the object seen by Klose "is the explosion volcanic crater of Malha, Sudan," and gives references to descriptions of this crater in *The Geographical Journal*, **82**, 116, 1933, and *The Quarterly Journal of the Geological Society*, **91**, 360, 1935.

The following assumptions seem to have been widely accepted: (1) that many of the differences between craters of volcanic and meteoritic origin would be best seen by airplane observers; (2) that meteorite craters, even the smaller and therefore presumably more numerous ones, would be easily discoverable by search from the air. Such examples as Klose's North African crater lead us to question the first assumption. As to the second, there are both theoretical and observational reasons for doubting that on ordinary military and commercial flights conditions are indeed favorable for the discovery of meteorite craters. These points will be elaborated in a forthcoming paper on a possible meteorite crater in the Aleutian Islands.

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Secretary of the Society: OSCAR E. MONNIG, 1010 Morningside Drive, Fort Worth 3, Texas

VARIABLE STARS

Variable Star Notes from the American Association of Variable Star Observers

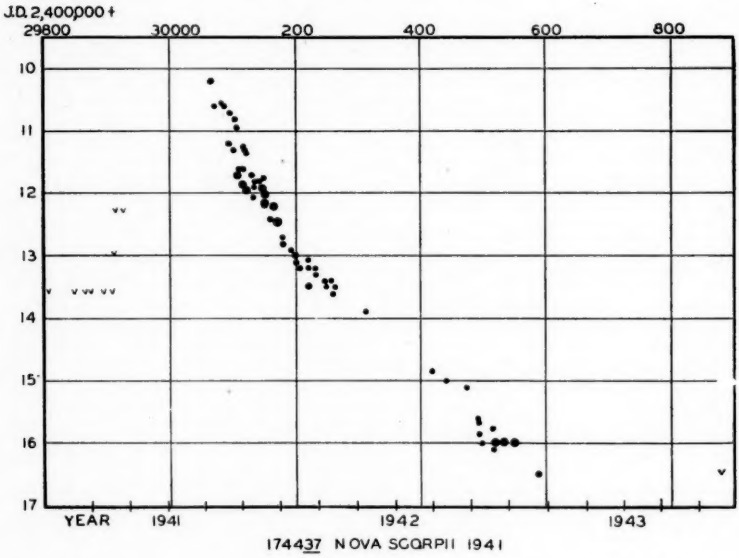
By LEON CAMPBELL, Recorder

Another 1941 Nova: In the course of examining the Harvard spectrum plates taken in 1941, Mrs. Mayall found another nova in Scorpio, which increases to two the number of novae which appeared that year, and which were detected solely by their spectral characteristics. (See these notes for May, 1943, on Nova Sagittarii 1941.)

Nova Scorpii 1941, located in R.A. $17^h\,44^m\,29^s$, Decl. $-37°\,35'.2$ (1900) was found on five spectrum plates taken with the 10-inch Metcalf telescope at Bloemfontein, between May 6 and July 27, 1941. The spectra are all of well-developed nova-type, exhibiting broad emission lines of Hβ, γ, δ, ϵ, and ζ, as well as the forbidden OIII lines, N_1 and N_2. In each instance Hγ is of intensity 5, Hδ, intensity 2, and the other lines of intensity 1. Maximum brightness was evidently

attained during the winter of 1940-41. Plates taken during September and October, 1940, showed no trace of the nova brighter than magnitude 12.5. On March 9 and 10, 1941, the star was estimated as of magnitude 10.0 and decreasing in brightness. On several plates taken during the summer of 1941 there was visible around the central image a nebulous ring, a feature typical of several other novae. In August, 1942, the nova was of magnitude 16.5, while in 1943 it was not seen and was not brighter, at least, than magnitude 16.5.

The light curve of Nova Scorpii 1941, as derived by Mrs. Mayall from Harvard photographs, is shown in the accompanying figure.



174437 NOVA SCORPII 1941

A Pre-discovery Observation of Nova Puppis 1942: Dr. Sergei Gaposchkin, in a survey of variable stars on Harvard Plates, has found two images of Nova Puppis 1942, separated by about 15 minutes, which give the brightness of the nova about four hours earlier than the original discovery observation by Professor Dawson on November 8. Dr. Gaposchkin reports that the Nova was then definitely brighter photographically than ε Canis Majoris, exceeded only by Sirius and Canopus. On the IPg scale the estimated magnitude was 1.1 on J.D. 2430672.54.

It is worthy of note that the rate of decline of the nova is about the same photographically and visually, the color index being about 0.7 magnitude. The photographic magnitude before the outburst was below or equal to 17, indicating a photographic range in brightness during the outburst of at least 16 magnitudes, or a total increase in intensity of about three million times.

Maxima of Bright Long-Period Variables, 1947: Predicted dates of maxima for the long-period variables on the AAVSO observing list which attain a mean magnitude brighter than 8.0 are listed herewith.

PREDICTED DATES OF MAXIMUM, 1947

Design.	Name	Date of Max. m d	Mean Max. Mag.
0010*32*	S Scl	12 10	6.8
001755	T Cas	12 1	7.8
001838	R And	12 10	7.0
021143a	W And	10 7	7.5
0214*03*	o Cet	10 22	3.7
0228*13*	U Cet	3 26 11 16	7.5
023133	R Tri	8 24	6.3
0250*50*	R Hor	12 9	6.0
0432*63*	R Ret	2 13 11 18	7.7
050953	R Aur	1 2	7.8
0515*33*	T Col	1 21 9 3	7.6
054920a	U Ori	1 24	6.6
0556*86*	R Oct	4 2	7.9
0652*08*	X Mon	1 1 6 6 11 9	7.6
065355	R Lyn	4 23	7.9
070122a	R Gem	2 15	7.1
072708	S CMi	2 2 12 30	7.5
0728*20b*	Z Pup	8 7	7.9
081112	R Cnc	5 5	6.8
0824*05*	RT Hya	5 26	7.6
084803	S Hya	2 9	7.9
0850*08*	T Hya	6 21	7.7
0929*62*	R Car	9 3	4.6
093934	R LMi	10 13	7.2
094211	R Leo	6 11	5.9
1006*61*	S Car	3 6 8 2 12 29	5.7
103769	R UMa	5 15	7.6
1144*41*	X Cen	3 6	7.8
1214*18*	R Crv	4 29	7.6
122001	SS Vir	2 12	6.9
123160	T UMa	5 11	7.9
123307	R Vir	3 24 8 16	6.9
123961	S UMa	2 16 9 30	7.9
1324*22*	R Hya	5 24	4.6
1327*06*	S Vir	3 25	7.1
1331*55*	RV Cen	12 1	7.6
1336*33*	T Cen	1 24 4 24 7 23 10 21	6.1
134440a	R CVn	8 10	7.7
1409*59*	R Cen	2 8	5.9
143227	R Boo	2 17 9 27	7.3
151731	S CrB	8 12	7.5
1518*22*	RS Lib	5 7 12 10	7.7
1528*49*	R Nor	2 11 7 17	7.2
1536*54*	T Nor	3 19 11 16	7.4
154615	R Ser	7 29	6.8
154639	V CrB	5 19	7.4
1621*12*	V Oph	4 29	7.5
162119	U Her	7 7	7.6
163266	R Dra	5 29 10 21	7.6
164715	S Her	9 20	7.6
1648*44*	RS Sco	1 14 11 30	6.8
1650*30a*	RR Sco	4 10	6.0
1702*15*	R Oph	10 7	7.6
1821*33*	RV Sgr	1 24 12 8	7.8
183308	X Oph	10 3	6.9
190108	R Aql	6 13	6.3
1910*19*	R Sgr	5 31	7.2
193449	R Cyg	1 22	7.3
194048	RT Cyg	2 24 9 2	7.4
194632	Chi Cyg	6 21	5.3
1946*59*	S Pav	6 22	7.3
1949*29*	RR Sgr	8 2	6.6
1951*42*	RU Sgr	4 7 12 3	7.2
200938	RS Cyg	4 20	7.4
2011*39*	RT Sgr	4 14	7.9
201647	U Cyg	10 1	7.6
2044*05*	T Aqr	2 18 9 8	7.9
210868	T Cep	3 27	5.8
2219*48*	S Gru	1 3	7.8
230110	R Peg	1 2	7.9
230759	V Car	7 6	7.9
2338*15*	R Aqr	6 29	7.3
2351*50*	R Phe	2 12 11 5	7.8
235350	R Car	9 1	6.5

A forthcoming A.A.V.S.O. Bi-monthly Bulletin containing a list of predicted dates of maximum and minimum for 1947 for nearly 400 long-period variables may be secured while available by addressing the A.A.V.S.O. Recorder, Harvard Observatory, Cambridge 38, Mass.

A Proposed Association of Italian Variable Star Observers: In a recent issue

of the Italian magazine, *Coelum*, appears an article by Professor Horn-d'Arturo, director of the Observatory of the University of Bologna, containing a suggestion that the variable star observers in Italy form a variable star association, somewhat similar to the A.A.V.S.O. and the one which flourished in France before the war, the A.F.O.E.V. The medium of publication for the observations will be *Coelum*, now in its 16th year as an astronomical magazine.

Italy has for many years been the seat of much variable star activity. Such names as Lacchini, Loreta, Jacchia, Ancarani, and Benini, have figured in the observational programs and, with the Lojano telescope at Bologna and the AAVSO reflector now at Faenza, there should be good incentive for variable star observers to band together and initiate an observing program such as was maintained prior to World War II. Success to the proposed variable star association.

Observations received during November: A total of 4,863 observations were contributed by 69 observers, as listed herewith:

Observer	No. Var.	No. Ests.	Observer	No. Var.	No. Ests.
Ahnert, F.	5	33	Koons	65	77
Ahnert, P.	40	297	Kotsakis	19	21
Ball	9	14	Larkin	1	1
Bappu, M. K.	18	34	Ledbetter	34	53
Bappu, M. K. V.	23	38	Luft	2	9
Blunck	5	5	Meek	66	158
Bogard	4	9	North	15	76
Boone	29	29	Oheim	89	100
Bouton	16	18	Oravec	26	95
Buckstaff	13	23	Parks	25	43
Chabot	6	21	Peltier	170	232
Chassapis	115	578	Plakidis	23	65
Cilley	34	49	Raphael	17	107
Dafter	6	14	Rayna	3	3
Damkoehler	3	4	Reeves	2	4
Darnell	2	10	Renner	100	100
Fernald	317	1,036	Rosebrugh	15	76
Fleischer	1	1	Schoenke	16	16
Garneau	11	12	Seagraves	6	6
Garrison	1	1	Segers	18	48
Halbach	32	32	Sherman	7	9
Hare	2	2	Smith, S. M.	3	4
Harris	21	21	Sochard	4	4
Hartmann	154	166	Stahr	3	12
Helfer	12	39	Taboada	36	36
Howarth	13	13	Thomas	10	21
Hukill	3	44	Treadwell	5	5
Itzigsohn	52	112	Wade	9	55
Kearons	51	60	Webb	30	31
Kelley	5	25	Weber	23	23
Kelly	16	20	Welker	37	71
Kilby	5	5	Welles	7	21
Kitley	38	63	Zirin	21	21
Knott	2	2			
de Kock	97	419	69	totals	4,863
Kohn	4	11			

December 16, 1946.

Comet Notes

By G. VAN BIESBROECK

No bright comets are observable at this time. Only one comes in reach of moderate-sized instruments and even this object, COMET BESTER, is visible only at low altitude. Its discovery was reported last month (p. 552) and an ephemeris given there. Observations show that this prediction is fairly close as far as brightness is concerned. In January the altitude is a little less unfavorable but the brightness already decreases. The comet appears as a fairly large hazy spot with a faint central condensation.

The other comets under observation at present are all much fainter. COMET TIMMERS is no longer in reach in the western sky. In the first part of the night periodic COMET TEMPEL 2 and BROOKS can still be reached with large telescopes but both are losing in brightness. PERIODIC COMET SCHWASSMANN-WACHMANN 1 (1925 II) was recorded here on November 29 and December 4 as a little coma of magnitude 17 and 16, respectively. It is very well located in Gemini and deserves continuous attention in order to catch some of the unexpected outbursts of brightness which have characterized this unusual object in the past. The ephemeris by P. Herget is as follows (*Harv. Card* No. 777):

	α (1950.0)	δ (1950.0)
	h m	° ′
1946 Dec. 30	6 31.0	+31 9
1947 Jan. 7	27.0	8
15	13.2	31 4
23	19.6	30 58
31	16.5	51
Feb. 8	14.1	42
16	12.4	33
24	11.3	23
1947 Mar. 4	6 10.9	+30 12

The field of PERIODIC COMET BORRELLY was explored in the morning sky of December 4 by the writer but no suspicious object brighter than 17 magnitude could be detected. This comet passed perihelion last June 22 and is evidently too faint after that long interval. It will therefore remain unobserved at the most unfavorable apparition. From all appearances PERIODIC COMET SCHWASSMANN-WACHMANN 3 will also go by unobserved at this return which was very unfavorable for northern observers. In the latter part of January, 1947, COMET JONES which was discovered on August 6 (see p. 420) will emerge from the sun's vicinity so that northern observers may have a chance at this object after that time. It will be a morning apparition and probably be reduced to 9th magnitude.

Williams Bay, Wisconsin, 1946 December 14.

General Notes

The Rittenhouse Astronomical Society held its monthly meeting on December 13, 1946, in the Morgan Physics Laboratory, University of Pennsylvania. The speaker was Dr. John Q. Stewart, of Princeton University Observatory, whose topic was "A New Use for Astronomy."

Amateur Astronomers League

Word has been received that the last of the requisite number of adherents to launch the organization named above, as indicated in a note on page 492 of the number for November last, was received on November 15. Therefore, the Amateur Astronomers League is a going concern beginning with that date. Astronomical groups and societies, which may not as yet have done so, may still become members of the League by sending application to James B. Rothschild, P. O. Box 281, Wharton, New Jersey.

The Cleveland Astronomical Society

The Christmas meeting of the Cleveland Astronomical Society was held on Friday night, December 13. Before introducing the speaker Dr. Nassau linked astronomy with the Christmas season by seeking an explanation for the Star of Bethlehem. He enumerated a number of suggestions and stated that the astronomical facts rule out each one.

Dr. J. J. Weigle, visiting professor of physics at Case School of Applied Science and professor of physics at the University of Geneva, Switzerland, gave an interesting, kodachrome illustrated, lecture on the Swiss Alps. The speaker thrilled the audience with his pictures and by relating his climbing experiences in the Alps. Refreshments followed the lecture.

HENRY F. DONNER.

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Eclipse Expedition Plans

Brown University and the Skyscrapers, Rhode Island astronomical organization, will jointly sponsor an expedition to Brazil to observe the total eclipse of the sun which will occur May 20, 1947.

The party of eight making the trip are all experienced eclipse observers and will be led by Professor Charles H. Smiley, director of Brown University's Ladd Observatory. The expedition will leave Providence about April 1, and will journey by ship to Rio de Janeiro from which point they will proceed over-land to Araxa, which is located in the state of Minas Geraes about 300 miles northwest of Rio de Janeiro.

Araxa has been chosen as an observation point for several reasons. It lies directly in the path of the eclipse which will sweep northeast across the continent of South America from central Chile to northeastern Brazil. Araxa is especially suitable because of its altitude and distance from the coast which make chances for clear skies better. It can be reached by railroad and local accommodations are good.

Professor Smiley states, "Modern devices including highly selective color filters allow astronomers to observe the *inner* corona of the sun on almost any clear day, but to date no instrument has been devised which will allow the observation of the *outer* corona and the measurement of its brightness except at total solar eclipses."

Professor Smiley will be accompanied by Mrs. Smiley on the expedition. The party expects to stay in Brazil a few weeks after the eclipse for the purpose of making other astronomical observations.

The Day of the Week Corresponding to a Given Date

A method for identifying a given date with the corresponding day of the week was given, for the Gregorian calendar, by Mr. Wolfgang Schocken's formula on pages 206 and 439 of POPULAR ASTRONOMY for April and for October, 1946. A somewhat shorter and more general formula was quoted from C. Zeller (*Acta Mathematica* 1887, Stockholm, vol. IX, pp. 131-136) by W. W. Rouse Ball page 242 of his "Mathematical Recreations" 1896. After adjusting the nomenclature we quote "If the Dth day of the Mth month of the year Y anno domini is the Rth day of the week reckoned from the preceding Saturday, then R is the remainder when (neglecting fractions)

$$D + 2M + [3(M+1)/5] + Y + (Y/4) - L$$

is divided by 7; provided January and February are reckoned as the 13th and 14th months of the preceding year, and $L = 0$ for Julian but for Gregorian dates

$$L = (Y/100) - (Y/400) - 2."$$

Ball illustrates application by these dates and notes that Pope Gregory decreed for the Roman jurisdiction October 5, 1582, was to be followed by October 16. Not until 1752 did England conform by dropping 11 days, and the year beginning was shifted from March to January, causing double dates for the interim such as January 30, 1648-1649.

Columbus landed Friday, October 12, 1492. Note that M = October = 10 $33/5 = 6$ $1492/4 = 373$. Hence $12 + 20 + 6 + 1492 + 373 - 0 = 1903$ which divided by 7 leaves R = 6 or Friday.

Charles I was executed Tuesday, January 30, 1649 O.S. Note that M = January = 13 $42/5 = 8$ and $1648/4 = 412$, so $30 + 26 + 8 + 1648 + 412 - 0 = 2124$ which divided by 7 leaves R = 3 or Tuesday.

Battle of Waterloo was fought Sunday, June 18, 1815. Note that M = June = 6 $21/5 = 4$ $1815/4 = 453$ $L = 18 - 4 - 2 = 12$, so $18 + 12 + 4 + 1815 + 453 - 12 = 2290$ which divided by 7 leaves R = 1 or Sunday.

Today is Saturday, September 28, 1946. Note that M = September = 9 $30/5 = 6$ $1946/4 = 486$ and $L = 19 - 4 - 2 = 13$, so $28 + 18 + 6 + 1946 + 486 - 13 = 2471$ which divided by 7 leaves R = 0 or Saturday.

Still shorter procedure ultilizes the Julian Day Numbers tabulated in the *American Ephemeris and Nautical Almanac*, where the zero date is Monday, thus

Columbus 1492	Waterloo 1815
2266010 leap year	2383974 common year
286 = October 12	169 = June 18
2266296/7 leaves	2384143/7 leaves
count 4 to Friday	count 6 to Sunday
Charles 1649	Today 1946
2323345 O.S. adds 10	2431821 common year
40 to January 30	271 = September 28
2323385/7 leaves	2432092/7 leaves
count 1 to Tuesday	count 5 to Saturday.

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Tycho Brahe Quadricentennial

The 400th anniversary of the birth of the Danish astronomer and scientist, Tycho Brahe, was commemorated with appropriate ceremonies at the Rensselaer Polytechnic Institute, Troy, N. Y., on the evening of December 17. Two addresses were delivered on this occasion, one by Dr. Samuel Rezneck, Professor of History at the Institute, and one by Dr. Roy K. Marshall, Director of the Fels Planetarium in Philadelphia. The former dealt with the age in which Tycho lived, the latter, with Tycho himself, his instruments and his work.

Book Review

The Earth and the Stars, by C. G. Abbot. (D. Van Nostrand Co., Inc., New York, 1946. xii + 288 pages, $3.75.)

Designed for the general reader, this book presents a general picture of the universe in non-technical language. The author does not confine himself to a straight-forward exposition of facts, but points out as well some of the philosophical implications of astronomy.

The text is divided into two parts. Part I, "The Mighty Universe," is entirely about the stars: their constellations, numbers, distances, motions, character, variability, and evolution. The title of Part II, "Interesting Astronomically Related Subjects," might mislead the reader into believing that the science of astronomy is concerned solely with stars, for under this heading are chapters on stellar spectra, the solar system, and solar eclipses. More properly included under such a title are the sections on famous astronomers and instruments, the calendar, navigation, and the subject of heat and power from sun rays. Dr. Abbot, who is known for a number of noteworthy achievements in solar research, gives an interesting and informative discussion of solar engines not usually found in a book of this nature.

Throughout the text, the author keeps his language and explanations simple, often using a familiar analogy to illustrate a point. Indeed, the serious reader, who is interested in delving rather deeply into the subject, may be annoyed by the occasional sacrifice of a completely lucid explanation because the author feels it would involve too technical a vocabulary. The reader who is impressed by the romance of astronomy, however, or who has no previous knowledge of this science will probably find this book an easy and enjoyable one with which to begin his study.

In 1925 Dr. Abbot published a book under the same title. Although the new book is not called a revision of the earlier volume, it is an expanded version, the chief difference lying in the rearrangement of the material.

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